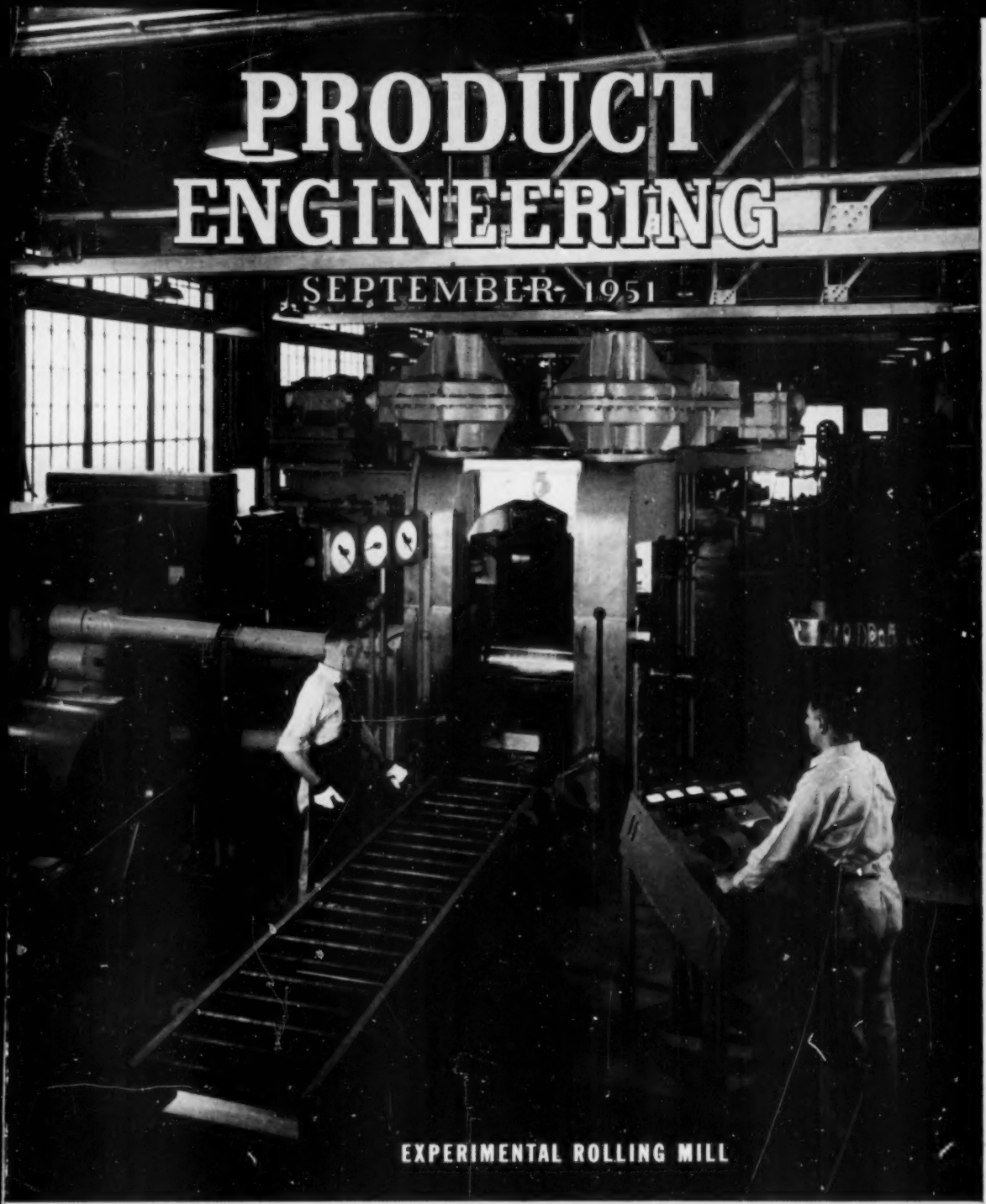
PRODUCT ENGINEERING

SEPTEMBER, 1951



EXPERIMENTAL ROLLING MILL

IN THIS ISSUE—Controlling Design Changes ✦ Vibration Pick-Ups ✦ Metal Adhesives ✦ Torsional Failure ✦ Instrument Gears ✦ Dimensioning Springs

A McGRAW-HILL PUBLICATION
FIVE DOLLARS A YEAR

Front Line Protection...

MADE OF SHARON* SPECIAL DEEP DRAWING HELMET STEEL

The designer of this head piece may never be listed alongside Dior or Dache, and the wearer quite probably will receive no Fashion Academy Award for originality, but there is no denying its popularity.

The steel used in the manufacture of this standard military helmet necessarily must be tough — yet pliable enough to take an extra-ordinarily deep draw without strain. It is made of a single piece of strip steel which has cold work hardening properties to stand maximum impact.

Expanding military requirements call for an ever increasing number of these helmets. As in World War II, a large percentage of them will be made from Sharon special deep drawing helmet steel.

* **Specialists in STAINLESS, ALLOY, COLD ROLLED and COATED Strip Steels.**

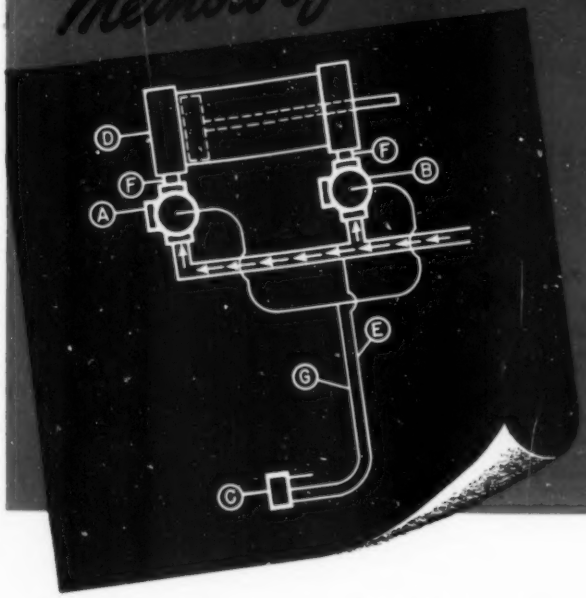
SHARON STEEL CORPORATION

Sharon, Pennsylvania

DISTRICT SALES OFFICES: CHICAGO, ILL. CINCINNATI, O. CLEVELAND, O. DAYTON, O. DETROIT, MICH. INDIANAPOLIS, IND. MILWAUKEE, WIS. NEW YORK, N. Y. PHILADELPHIA, PENNA. ROCHESTER, N. Y. LOS ANGELES, CALIF. SAN FRANCISCO, CALIF. MONTREAL, QUE. TORONTO, ONT.

SHARONSTEEL

How to Boost Production with new Method of Mounting Ross Valves



★ Faster Machine Speeds

★ Less Air Consumption

★ Economical Installation

★ Easier Operation

Close-coupling of valve to cylinder! That's the story behind the remarkable success of the *new Ross In-Line Master Valve.*

Users claim several important advantages. By placing the master valves (A & B) at the cylinder (D), air supply and exhaust are speeded up appreciably. This in turn permits faster movement of the cylinder piston and materially increases production.

At the same time, the close coupling means that two lengths of large diameter piping between valve and cylinder—pipes continually filled and exhausted with non-productive air—are replaced by two short connecting pipes (F). The resultant saving in air with every movement of the piston considerably reduces operating costs.

Operation is by a small, conveniently located 3-way pilot valve (C). It is supplied through tubing (E) and connected to the master valves by tubing (G). It may be mechanically, manually or electrically controlled. Hand or foot operation is greatly facilitated by the use of the smaller, more easily actuated pilot model.

The complete story of possible advantages in *your* production will be gladly furnished without obligation. Ask for Bulletin No. 302.

Ask Ross for Any Air Control Information

Ross makes valves only -- hundreds of types and sizes. Take advantage of the experience gained in over a quarter century of concentration on control and application of air power!

ROSS OPERATING VALVE COMPANY

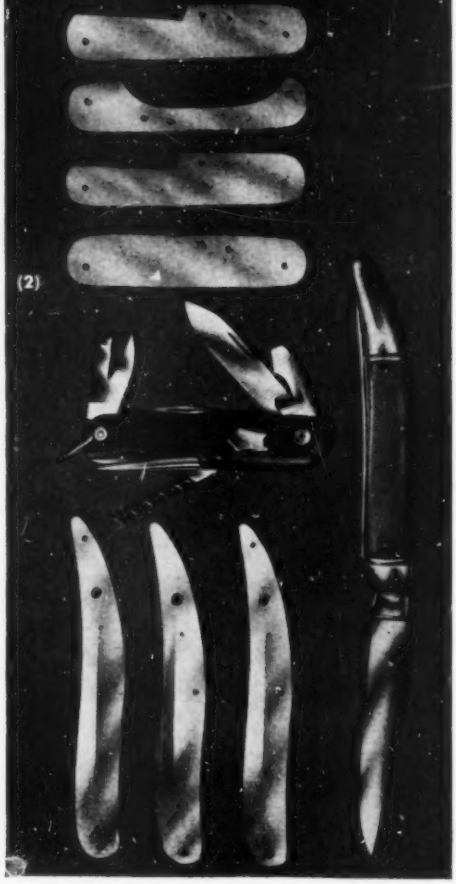
ROSS Air Control VALVES

120 E. GOLDEN GATE AVE., DETROIT 3, MICHIGAN

VALVE BODIES or PENKNIVES

(1)

(2)



How Two Manufacturers Improved Their Products . . . Pared Their Production Costs

(1) This illustration shows only four steps in the manufacture of a valve body from Revere 70-30 Cartridge Brass by Eastern Tool & Stamping Co., Saugus, Mass. Eastern was asked to quote on making this body as a stamping, to replace a casting. Due to the design of the part, it was felt that it would be especially difficult to produce from brass strip. Hence Revere was asked to collaborate on specification and fabrication. A close study of the fabrication steps resulted in the recommendation of 70-30 brass in a certain grain size. The latter is kept under control by Eastern through only two intermediate anneals. The result is a most unusual drawn and formed part, lighter, better, and more economical than the former casting. (Revere has no objection to castings as such. The important thing is to use them only if they are more economical and satisfactory.)

(2) Penknives, fisherman's knives and similar items made by the Utica Cutlery Company, Utica, N. Y., contain liners of brass which provide the proper clearances between the blades. These not only have to be blanked to the proper shape, but also must be punched with small holes for the rivets. Some of the holes must be "punched clean" with a minimum amount of burr. Others are produced with a blunt punch so that the metal is extruded slightly around each hole. The Revere Technical Advisory Service was consulted, with the result that Revere now supplies brass in a temper which blanks cleanly, but which also produces the exact amount of extruded metal around the desired holes in the customer's operation. In this case, it was proper temper which eliminated rejections and added to the quality of these already fine knives.

• These two cases are typical of the results obtainable when Revere and a customer sit down together to share their knowledge with each other. In these times, when more and more companies are planning to switch to Defense Orders, such collaboration can be exceptionally valuable. May we work with you?

REVERE 150TH YEAR OF SERVICE TO AMERICA

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

• • •

Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.

SEE "MEET THE PRESS" ON NBC TELEVISION EVERY SUNDAY

VOLUME 22 — PRODUCT ENGINEERING — NUMBER 9

G. F. NORDENHOLT, *Editor*
Assistant to the Editor, Joseph Kerr • *Managing Editor*, V. H. Laughner
Associate Editors, J. D. Cooney, E. S. Cobb • *Assistant Editors*, P. F. Horbatt, P. J. Rochford, R. P. Dominic, N. J. Van Ness, C. R. Tobin • *Editorial Assistant*, P. N. Anderson
Consulting Editor, Robert E. Bruckner • *Washington*, George B. Bryant, Jr.
Assistant Publisher, W. E. Kennedy • *Advertising Sales Mgr.*, Stanley J. Alling • *Service Mgr.*, Hugh Britton
Publisher, Albert Hauptli

Foreign News Bureau: London • Paris • Berlin • Moscow • Tokyo • Melbourne • Rio de Janeiro • Buenos Aires • Manila

SEPTEMBER 1951

Controlling Engineering Design Changes by Allan T. Wilson 119
How to make design changes without confusing yourself and the factory.

Selecting Engineering Adhesives by Frank W. Reinhart 123
Essential principles of selection and application of adhesives, including joint design details.

Product Designs 130
Earthmover steering assembly; lightweight escalator; Tube labeler; Mist lubricator.

Integral Finned Tubing by Walter P. Hill 140
Types of tubing and methods of selection for heat transfer applications.

Ready-Made Amplifiers for Transducer Signals by T. R. Breunich 143
Adaptation of conventional temperature recorders saves control design dollars.

Pneumatic Actuators for Remote Control Systems by D. P. Eckman and R. B. Wertz 151
Matching the characteristics of air-powered actuators to the load being moved.

Rectifier Circuits Using Diode Vacuum Tubes by Ralph B. Immel 156
Explanation of fundamental electronic circuits for the rectification of alternating current.

Magnesium Rare Earth Alloys by L. W. Eastwood 158
Physical properties of cast and wrought alloys having high creep resistance at elevated temperatures.

Design Recommendations for O-Ring Seals by J. H. Swartz 162
For effective seals in different applications, what design details are most important?

Electro-Dynamic Calibrators for Vibration Pickups by Robert C. Lewis 164
A method by which the performance of a pickup is compared to that of a known secondary standard.

Torsional Fatigue Failures by J. O. Almen 167
Evaluation of the stresses and the fracture characteristics developed by torsional loads in parts made of metal. Torsional stress diagram is developed for the analysis of surface and sub-surface stresses.

Practical Considerations in Instrument Gear Design by L. M. Davison 183
Reasons why undercut pinions should be avoided and effect of pressure angle on tooth accuracy.

Elastic Girdles for Ball Bearings by J. H. Stark 188
Simple method for mounting bearings without the need of close tolerances in housing dimensions.

Dimensional Tolerance Charts for Helical Springs by C. H. Sacks 199
Graphical method determines if springs with normal manufacturing tolerances will function properly.

Highlights 5
Front Cover 9
Available Materials 113
Editorial 117
Technical News 193
New Parts and Materials 204
New Catalogs and Bulletins 230A
Meetings 248
Engineering Abstracts 250
Sans Souci 262
Our Readers Say 270
New Books 281

September, 1951 — PRODUCT ENGINEERING — Vol. 22, No. 9

Published monthly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder. **Publication Office, 99-129 North Broadway, Albany, N. Y.**
Executive, Editorial and Advertising Offices: McGraw-Hill Building, 330 W. 42nd St., New York 18, N. Y. Curtis W. McGraw, President; Willard Chevalier, Executive Vice-President; Joseph A. Gerardi, Vice-President and Treasurer; John J. Cooke, Secretary; Paul Montgomery, Senior Vice-President, Publications Division; Ralph B. Smith, Editorial Director; Nelson Bond, Vice-President and Director of Advertising; J. E. Blackburn, Jr., Vice-President and Director of Circulation.
Subscriptions: Address correspondence to Product Engineering—Subscription Service, 99-129 N. Broadway, Albany 1, N. Y., or 330 W 42nd St., New York 18, N. Y. Allow ten days for change of address. Please indicate position and company connection on all subscription orders.
Branch Offices: ATLANTA, R. M. Maultsby; 1311 Rhodes-Haverty Bldg.; BOSTON, M. A. Williamson, Jr., 1427 Statler Bldg.; CHICAGO, Anson E. Manor, 520 N. Michigan Ave.; CLEVELAND, A. F. Fischer, 1510 Hanna Bldg.; DALLAS, J. H. Cash, First National Bank Bldg.; DETROIT, P. G. Weatherby, 856 Penobscot Bldg.; LOS ANGELES, J. H. Allen, 1111 Wilshire Blvd.; NEW YORK, J. A. McGraw and D. C. McGraw, Jr., 330 W. 42nd St.; PHILADELPHIA, David G. Jones, Architects Bldg.; PITTSBURGH, A. F. Fischer, 738-9 Oliver Bldg.; SAN FRANCISCO, J. W. Otterson, 68 Post St.; WASHINGTON, National Press Bldg.; LONDON, Aldwych House, Aldwych, W. C. 2, England.
Single copies 50¢. United States and possessions, $5 for one year, $8 for two years, $10 for three years; Canada, $6 for one year, $10 for two years, $12 for three years; Latin American countries, $15 for one year, $25 for two years, $30 for three years; all other countries $20 for one year, $30 for two years, $40 for three years. Entered as second class matter August 21, 1936, at the Post Office at Albany, N. Y., under act of Mar. 3, 1879. Printed in U. S. A. Copyright 1951 by McGraw-Hill Publishing Co., Inc.—All rights reserved.

Extra Savings in Design and Production . . . with *Mallory High-Density Alloy!*

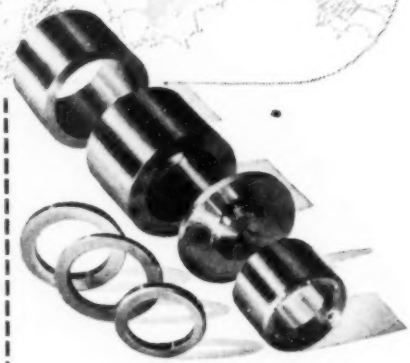
The list grows every day! Mallory non-ferrous alloys and ingenious applications are making big savings for more and more Mallory customers.

Here's an interesting example. Recently, a well-known manufacturer of aircraft instruments was faced with the necessity of increasing the stability of a gyroscope, in order to use it for larger planes. Plans included enlargement of the steel rotor . . . involved expensive re-tooling for the larger assembly. Mallory suggested that the rotor be made from readily-machinable, high-density Mallory 1000 Metal. Tests proved it to be ideal. The required stability was obtained with no increase in the size of the rotor or the gyroscope. Further . . . production delays and the expense of major re-designing were avoided.

That's service beyond the sale!

And whether your problem is metallurgical or electronic, what Mallory has done for others can be done for you!

In Canada, made and sold by Johnson Matthey & Mallory, Ltd., 110 Industry St., Toronto 15, Ontario



Mallory 1000

Mallory 1000 is a high-density metal whose density approaches that of pure tungsten, platinum and gold. It has great strength and is readily machinable. Its resistance to the corrosive action of many acids, as well as the atmosphere, is superior.

Mallory 1000 is ideal for uses where maximum weight in minimum space is required, such as gyroscope rotors, balance weights on crankshafts, variable-pitch propellers and centrifugal clutches. Its great density also makes it useful for shielding X-ray and gamma radiation.

As a leading producer of unusual alloys and materials from copper, silver, platinum, palladium, tungsten, molybdenum, aluminum-bronze, and nickel, Mallory is in a qualified position to make effective and impartial recommendations for materials best suited to your needs. Write today.

Metallurgical Products and Alloys

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Electromechanical Products
Resistors *Switches*
TV Tuners *Vibrators*

Electrochemical Products
Capacitors *Rectifiers*
Mercury Dry Batteries

Metallurgical Products
Contacts *Special Metals*
Welding Materials

Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

NONMETALLIC MATERIALS

SUBSTANTIAL SAVINGS in storage space and production time have resulted from the use of metal sheet precoated with a new bendable porcelain enamel. The 0.003-in. thick film is not damaged when the coated sheet is formed into stove and oven liners made by the Florence Stove Company of Kankakee, Illinois.

SYNTHETIC FILTER CLOTHS of Orlon, Vinyon, and Dynel have been added to the nylon line developed by Filtration Engineers, Inc., Newark, N.J. The cloths, called Feon Fabrics, are for all types of pressure and vacuum filters, centrifuges and dry filtration equipment.

NON-TRANSFERRING electrical tape adheres tightly to a dry surface even though it has been reapplied numerous times. Made by Goodrich of Koroseal material, adhesive has good electrical properties, comes in rolls 3/4 in. wide.

REFORMULATION of synthetic rubber O-ring compound 41 by Parker Appliance has raised upper temperature limit from 165 to 300 F, yet at lower limit of -65F, flexibility is still satisfactory. Compound resists corrosive agents and most oils, has Shore A hardness of 65 and elongation of 350 percent.

NON-ABRASIVE POLISH "brings up" the finish and acts as an anti-corrosion agent on 2S aluminum coating used over 24ST alloy airframe skins. Developed at Ryan Aeronautical of San Diego, Raco 220 contains four pounds of 400-mesh silica per gallon, plus additives that facilitate polishing.

COMBINING THE MERITS of alkyd and phenolic resins, Series 101-E finishes made by Kay & Ess Co., Dayton, Ohio, are finding many uses as coatings on appliances and automobiles. Features are durability, adherance, flexibility and resistance to chemicals.

DECORATIVE PARTS such as nameplates and radio grilles have attractive metallic appearance, yet amount of critical material used is small. Cellulose acetate is laminated to a synthetic base such as pressed board. Metallic silver is then vapor-deposited and imprinted in various colors. Type and thickness of base determine rigidity of the part. Makers are Coating Products, Inc. of New York City.

TRANSPARENT TUBING for electrical wiring retains flexibility and dielectric properties in range from -150 to +375 F. Fluoroflex "C" resists most corrosive agents and oil.

METALLIC MATERIALS

NICKEL CONTENT of International Nickel's new alloy, Incoloy, is 35 percent instead of about 70 percent as is the case with other high-temperature alloys it replaces. Remainder of composition is 20 percent chromium and the balance iron. Corrosion resistance is reported to be high, and expansion coefficients are slightly higher than those for the Inconel material.

COPPER-CLAD STEEL in standard sheet gages up to 48 in. wide and 132 in. long relieve the strain on critical copper in electrical shielding applications. American Cladmetals of Carnegie, Pa., roll commercially pure copper on one or both sides of SAE 1010 steel, call the combination ElectroShield.

IT'S A SAFE BET to use lead-base babbitts in most cases where critical tin-base bearings are in current use. Temperatures as high as 350 F are permissible. Main exception is when parts are exposed to organic acids, which present a corrosion problem.

STRESS CORROSION sometimes found in parts cast from bronze alloys is all but non-existent in 10 percent aluminum bronze if it's handled correctly. Trick is to cast, weld or quench in an

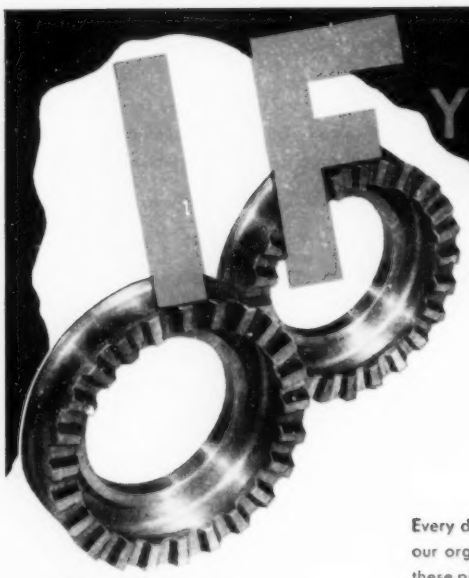
(continued on page 7)

IF YOUR PROBLEM IS

BEVEL GEAR OR CURVIC COUPLING DESIGN

MANUFACTURING EQUIPMENT

PRODUCTION TIME AND COSTS



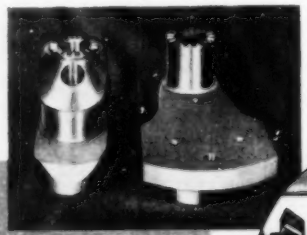
To help you . . .

THE DESIGN ENGINEER should provide us with preliminary layouts or prints of proposed bevel gear designs . . . type of drive, horsepower and speed . . . type of loading (constant, intermittent or shock) . . . type of material . . . driving member and direction of rotation.

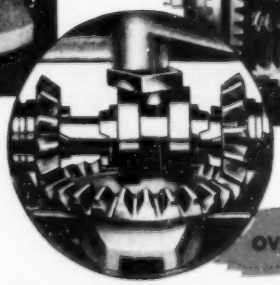
THE PRODUCTION ENGINEER should furnish blue prints, material specifications, manufacturing tolerances . . . quantity of gears to be produced . . . number of working hours available for production.

Every day highly skilled engineers within our organization provide the answers to these problems. Backed by the company's 85 years' experience in this field, our complete engineering service is at your disposal, without obligation, to study any bevel gear or Curvic coupling design problem you may have. We will be glad to make our recommendations as to the best design, the proper equipment and the most advantageous methods for reducing production time and costs.

SEMI-UNIVERSAL COUPLINGS



PERMANENT COUPLINGS



OVERLOAD CLUTCHES

BUILDERS OF BEVEL GEAR MACHINERY • FOR OVER EIGHTY-FIVE YEARS • GLEASON

GLEASON WORKS

1000 UNIVERSITY AVENUE · ROCHESTER 3, NEW YORK

atmosphere of ammonia. Tests were conducted at GE's Switch Gear Division in Philadelphia.

DUAL PLATING consisting of 65 percent tin and 35 percent nickel has recently been developed at

the Greenford, England laboratories of the Tin research Institute. This combination of codeposited metals may well take the place of conventional but critical nickel-chromium plating.

TITANIUM SPONGE is now being converted into sheet alloys that sell for one dollar a pound which is a fifth of previous quotations. Horizons, Inc. of Cleveland have turned the trick, with Navy backing, for use in aircraft structures.

COMPONENTS

TIME DELAY RELAY utilizes hydraulics as well as magnetism in its operation. Made by Heinemann Electric Co. of Trenton, N.J., the Silic-O-Netic relay has only one moving part in the time element. This part works in a sealed tube filled with viscosity-stable liquid silicone resin. Timer can be set for periods as long as four minutes. Overall dimensions are 1 5/8 by 2 1/2 by 3/4 in.; rated capacity is 10 amp, 110 volts.

SIX-INCH-RADIUS CORNERS are no problem for the Chain Belt Co.'s new Flex-Top conveyors. Crescent-shaped top plates are welded to links which are connected by universal joints of special design. Plates can therefore move in two planes within a short radius.

LATEST ADDITION to Bell Laboratories' family of tiny amplifiers is the junction transistor--a

plastic bead half the size of a pea from which three wire leads extend. Rod-shaped piece of germanium is treated so that an electrically positive layer is sandwiched between two negative layers. Power consumed is about one-millionth that required to heat a vacuum tube.

LEVEL CONTROL SWITCH works in conjunction with a sensing electrode that is positioned at controlling level. Liquids of most any viscosity, as well as solids can be handled by selecting the proper electrode. The Tektor switch housing is mounted outside the material container and connected to the electrode by a cable. Level differentials from 1/32 to 3/8 in. can be obtained. Fielden Instrument Corp. of Philadelphia.

TAPE RESISTORS have been put on a practical basis at the National Bureau of Standards. Material is carbon black or graphite, resin and solvent applied as a thin tacky layer to a roll of asbestos tape. A strip is cut to proper "ohmic" length and pressed onto an insulating base.

HIGH LOCKING PRESSURES feature the new Link-Lock device designed by Simmons Fastener Corp. of Albany, N.Y. The latch is attached through a pin to a disk rotated by a wing nut. Pin is eccentric to the disk so that when the latter is rotated past 90 degrees, pin passes dead center and locks latch in position.

SINGLE SPIDER GEAR takes the place of the customary two in the Ford Instrument Company's

new mechanical differential. To obtain smooth operation and equal friction in either direction, special curved-tooth bevel gears cut to zero-degree spiral angle are used. Unit is intended for precision applications in close-control instrumentation and analog computors.

PROCESSES

PLASTIC DIES are being used by Northrop Aircraft for fabricating light alloy parts. Pressures of 1,000 tons do not damage the thermo-setting die materials. Advantages are: Low shrinkage and wear, pattern accuracies of 0.0025 in. and tolerances of 0.005 in. between references.

MAGNESIUM-BASE ALLOYS can be treated electrolytically to develop a hydrated oxide coating that will take a dye. U.S. Patent 2,538,831, covering this subject was recently assigned to Consolidated Vultee Aircraft Corporation.

AN ULTRASONIC BATH for soldering small, complex aluminum parts used in electrical as-

semblies and instruments is the latest creation of Mullard Limited, London, England. Solder is melted in a 7/8 in. dia by 3/8 in. deep cavity. Parts are then immersed and the both vibrated at about 20 kcps. Oxide film on parts is broken up so that tinning is rapid and efficient.

LIGHT METAL SCRAP has been direct extruded experimentally as 5/8 in. dia bars that possess properties approaching those of new material. Aluminum and magnesium turnings, borings,

(continued on page 9)

Another development using

B. F. Goodrich Chemical Company *raw materials*

This valve a product of Dairy Whipt Division of Aerated Container Corp., Chicago, Ill.

Seal that puts the sale in Aerosol packages!

B. F. Goodrich Chemical Company does not make the aerosol or its components. We supply the raw materials for the valve seal only.

THESE ingenious aerosol, or "pressure" packages score a sales success everywhere. They're used for many products—from mist sprays to food and cosmetics. One of the tough problems in perfecting them was developing a valve that would provide a leak-tight seal. The valve had to contain a sealing compound that would also withstand oils, solvents, alkalies—and where necessary, be tasteless and odorless. When Hycar rubber sealing compounds were tried, they filled the bill on every count!

Because Hycar is so versatile, valves can be made to perfectly suit varying packaging requirements. One type helps "fluff" whipped cream. Another helps shampoo flow properly. Still another does a job of "misting" insecticides.

They're all examples of the wide variety of applications for Hycar. For Hycar can be compounded to resist gas, oils, solvents, detergents and other corrosive elements. It resists heat and cold, weather and wear. Continual or intermittent flexing has no effect on Hycar compounded parts.

Hycar is used in many ways, to develop or improve both civilian and defense products. Demand exceeds supply, but limited quantities are available for development work. For helpful technical advice, please write Dept. HL-5, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco.

B. F. Goodrich Chemical Company
A Division of The B. F. Goodrich Company

Need high elasticity? Hycar has it—plus extreme temperature resistance and more advantages.

Hycar
Reg. U.S. Pat. Off.
American Rubber

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON organic colors

foils and grindings are heated and compressed in a cylinder to a consistency of cold lead. Additional pressure is applied for forming the bars.

CARBONIZATION of gears is not new, but the process has recently been refined to the point of consistently limiting distortion to one ten-thousandth of an inch per foot of diameter. Engineers at Brad Foote Gear Works of Chicago have perfected heat treatment procedures so that gear cores have greater resilience, yet the hardened case retains high accuracy and durability.

SIGMA PHASE WELDING is more economical than Heliarc when it comes to butt welding heavy aluminum plate. Cleaning and finishing costs are lower. Deposition rates are higher, yet amount of rod consumed is relatively low.

TESTING

FLICKERING of the flames in a gasoline fire is the key factor in the operation of a new fire detector. A lead sulfide photocell sensitive to infrared radiations of a certain "flicker" frequency is the heart of the device. False alarms are avoided because radiations from sunlight or overheated parts have relatively constant frequencies. Photoswitch, Inc., Cambridge, Mass., reports unit "spots" a fire at ten feet.

A MILLION-POWER MICROSCOPE that uses only electronics plus lenses and magnets has been built at the University of Chicago. Designed for studying metals, instrument is cheaper to build than commercial units and has considerably greater magnification.

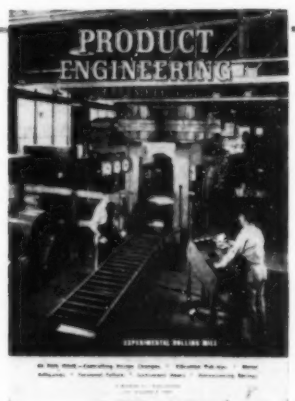
PRECIPITATION STATIC often causes interference in aircraft radio reception. A discharge system developed at State College of Washington solves this problem by momentarily blocking out the radio until corona intensity is reduced to a negligible level.

DETECTION of metal particles in non-metallic materials is the role played by RCA's Guardsman inspection devices. Material is fed through one of four different types of small-aperture inspection heads. Plastics, paper and rubber are typical materials handled by the device.

CURVE TRACES on an oscilloscope screen are, at best, tricky to record. Offner Electronics of Chicago make an instrument, the Dynograph, that records impulses as zig-zag lines on paper. As many as seven different traces can be handled simultaneously. Recording speeds are adjustable up to 1/120 second; accuracy is said to be within approximately one percent.

INFLAMMABLE GASES are the stock-in-trade of a portable meter made by Lor-Ann Instrument Co. of Jersey City, N.J. Six-pound circular instrument is of simple design, yet accurate and easily adjusted by rotating a pair of control knobs. Overall dimensions are diameter of 5 1/2 in. and height of 6 1/2 inches.

RECENT TESTS of low-carbon stainless steel's resistance to weld decay reveal that 18-8 of 0.08 percent carbon content fails under standard test conditions. A 0.03-percent carbon 18-8 sample treated with titanium exhibits almost perfect results. Tests are discussed by G.R. Bolsover in British journal, "Sheet Metal Industries".



THIS MONTH'S COVER

Versatility characterizes this new rolling mill at Alcoa's Aluminum Research Laboratories, New Kensington, Pa. By ready exchange of roll assemblies, it can be used as a 2-hi or 4-hi mill, and quickly adapted for either hot or cold rolling. Design of bearings, roll necks and rolls permits heating the rolls to 700 F. The rolls are 28 in. wide and the maximum roll opening is 5 in. Rolls of various diameters, ranging from 3.5 to 24 in. are available. The drive utilizes two reversible, variable-speed, 125 hp, d-c motors and a two-speed gear drive with ratios of 20.1:1 and 3.84:1. Linear roll speeds range from 28 to 1,700 ft per minute. Roll pressure, torque, speed and power input can be measured and recorded.

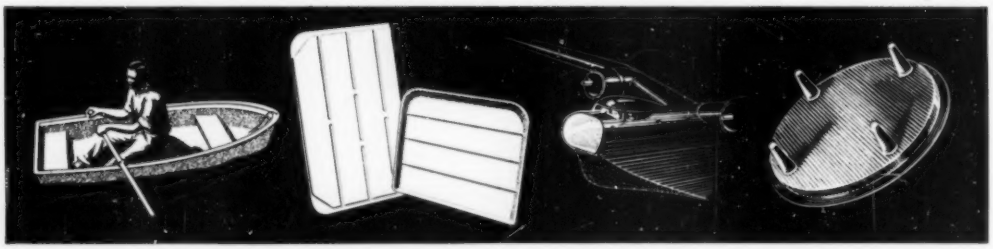
YOU TOO, MAY FIND NEW BUSINESS OPPORTUNITIES IN

REINFORCED Polyester PLASTICS

BAKELITE Polyester Resins constitute a fast-growing branch of the plastics industry. These resins are used in the production of reinforced plastics, chiefly with glass fiber mat or woven cloth. When properly formulated and applied they produce truly structural plastics with high strength-weight ratios that compare favorably with aluminum and steel. Present applications include boat hulls, refrigerator panels, radar housings, tote boxes, luggage.

In general, BAKELITE Polyester Resins provide excellent resistance to moisture, many chemicals, heat and cold. Certain types have excellent electrical characteristics including electrical "transparency" for radar housings. Another type can be cast into strong transparent solids. Another type is highly flexible and is used to impart added toughness to the other Polyester Resins. Inorganic fillers can be incorporated in certain of these resins to reduce costs and to minimize cracking and crazing.

Because BAKELITE Polyester Resins are "tailor-made" to meet widely different chemical, physical, and electrical requirements, Bakelite engineers will gladly assist you in choosing the right resins or combinations of resins for the intended end use. Write Dept. CL-10 for technical assistance and for latest data on the principal BAKELITE Polyester Resins now being marketed.



BAKELITE Polyester Resins are products of a continuing program of research and development. The principal grades now offered are:

High Viscosity Polyester Resin QRS-179 An excellent casting resin. May be prepared at room or elevated temperatures.

Med. Viscosity Polyester Resin QRS-147 A general purpose liquid resin with very good molding characteristics and excellent electrical properties. Adaptable to molding at room and elevated temperatures.

Low Viscosity Polyester Resin QRS-176 A low viscosity polyester resin which can be efficiently drawn into laminating layup under vacuum.

Heat Resistant Polyester Resin QRS-142 Generally similar in properties to QRS-147, it is designed to yield higher heat distortion points according to ASTM D 648-45T test method.

Flexible Polyester Resin QRS-136 For application where flexibility is desired. Also is completely compatible permanent plasticizer with other polyester resins to impart special properties.

BAKELITE
TRADE-MARK
POLYESTER RESINS

TRADE MARK

BAKELITE COMPANY
A Division of
Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York 17, N.Y.

No ONE chain serves every purpose

LINK-BELT offers the right chain

. . . engineered for your requirements

Don't settle for a "cure-all" chain to handle every job. Different types of chain have different characteristics. That's why Link-Belt makes the most complete line of chains in the world. Our engineers can recommend the exact type of chain to fit your particular needs . . . the one that does your job best.

Equally important is your assurance that *any* chain with the Link-Belt name will give you longer chain life. Exact control of raw materials and processes . . . plus manufacturing refinements add up to the highest standards.

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, factory branch stores and distributors in principal cities. 12,506 A

LINK-BELT

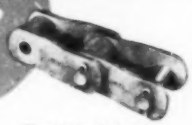
CHAINS AND SPROCKETS

This corn harvester is equipped with Steel Link-Belt, with special attachments, for gathering and conveying the corn. Link-Belt Precision Steel Roller Chain drives the wagon elevator.

Typical chains from the complete LINK-BELT line

Class H Pintle chain—excellent for conveyors that slide, because of broad wearing surfaces.

Class C combination chain—popular, durable, low cost design for elevators, conveyors.



Class SS bushed roller chain with offset sidebars—for heavy drive service at moderate speeds.

Class 400 swivel chain—carries cartons, cases, etc. over paths with both vertical and horizontal turns.

Designer's

Standard motors can be foot-, sidewall-, or ceiling-mounted for a wide variety of applications. Wherever they can be used, they are less expensive and can be shipped sooner than special motors. Installation is quick and easy, and they can often be shifted from one job to another in an emergency.

MOTOR MOUNTINGS FOR EVERY MACHINE

—to simplify your design job!

One of the big time-saving advantages of Tri-Clad induction motors for designers today is the wide variety of motors and motor modifications available in the line. You can literally specify one for almost every conceivable type of mounting —usually right out of the catalog—that will simplify your design job, save space, and cut assembly costs.

This versatility of mounting is basic with both the open (drip-proof) and the popular totally enclosed lines, each comprising a wide range of ratings. Where the motor is to become a part of your machine, a Tri-Clad motor mechanical modification—like the few shown below—can improve appearance, add convenience, and save space and weight.

And because they're all Tri-Clad motors, you have industry-proved 3-way extra protection—against physical damage, electrical breakdown, and operating wear and tear. For the "inside story" on Tri-Clad motor toughness, see Bulletin GEA-3580.

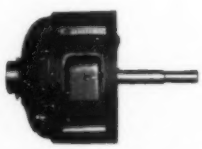
TRI CLAD
REG. U.S. PAT. OFF.

INDUCTION MOTORS

Face-type motors are used where motor supports machine, by means of bolts which screw into tapped holes in motor's end shield. Supplied with or without feet.

Flange-type motors are for use where machine supports motor, attached by bolts tightened from motor side of end shield's mounting surface. Supplied with or without feet.

Vertical motors are for direct coupling to vertical machine shafts. The Type P base conforms to NEMA standard dimensions.



Partial motors, built right in or closely coupled to the machine, are supplied less one or more components—end shields, bearings, shaft.

GENERAL ELECTRIC

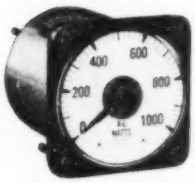
Digest

GE PRODUCT HIGHLIGHTS

MANUAL SWITCHES
—for simplest motor-starting!

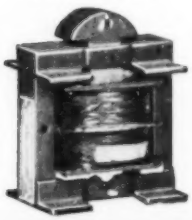
As easy to use as a home light switch is this General Electric manual motor-starting switch. Available with overload protection in both push-button and toggle-operated types, it's the simplest way to control infrequently started small motors. Mounting and wiring are simplified, too, because of front-connected terminals, easy-to-reach knockouts, roomy case. For 1 to 7½ hp, 1-, 2-, or 3-phase a-c motors, or for d-c motors up to 2 hp. See Bulletin GEA-1522.

SWITCHBOARD INSTRUMENTS
—long scale and shadow-proof!



Newly designed shadow-proof covers on these G-E long-scale switchboard instruments now make possible quick, accurate readings even under sharp-angle lighting conditions. They are enclosed in dust-tight, moisture-resistant cases designed for semi-flush mounting and reduced behind-the-panel depth. You can obtain these shadow-proof instruments as ammeters, voltmeters, and wattmeters; frequency and power-factor meters; temperature indicators and synchroscopes in either 4¼- or 8¾-inch sizes—all accurate to ±1 percent. See Bulletin GEC-218B

HEAVY-DUTY SOLENOIDS
—for precision push or pull!



When your machine needs a straight-line push, pull, or reciprocating motion, you'll get a reliable, precision job with General Electric heavy-duty solenoids. Designed especially for long life in industrial service, they're available in a complete line, continuously rated, for a-c or d-c. Ratings range from a ¾-inch stroke at 0.65-lb thrust to 3-inch stroke with a thrust of 97 pounds. Ratings and full description, plus condensed data on how to select a solenoid, are contained in Bulletin GEA-5163.

Wall-mounted type (above) comes in ratings from ¾ to 7½ kw.

Floor-mounted type (right) is available in 10- to 25-kw ratings.

NOW...

PACKAGED METALLIC-RECTIFIER POWER SUPPLIES

. . . for easy specifying, fast installation, low maintenance, flexible operation!

Here is a line of packaged a-c to d-c conversion units that's easier to specify and install, lowers unit costs, and speeds shipments. Made up of standard subsections, unit comprises selenium rectifier stacks, insulated transformer with taps to adjust for 10 per cent line voltage variation, and optional auxiliary control—all mounted in a metal enclosure. For flexibility or added capacity, two or more units can be placed in series or in parallel. Absence of moving parts (except for fan-cooling in larger units) cuts need for maintenance. See new Bulletin GEA-5658.

General Electric Company, Section J 668-90
Schenectady 5, New York

Please send me the following bulletins:

- ☐ for reference purposes
- ☐ in connection with immediate projects

  - ☐ **GEA-1522 Manual motor-starting switches**
  - ☐ **GEA-3580 Tri-Clad induction motors**
  - ☐ **GEA-5163 Heavy-duty solenoids**
  - ☐ **GEA-5658 Metallic-rectifier power supplies**
  - ☐ **GEC-218 Switchboard instruments**

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

NAME _____

COMPANY _____

STREET _____

CITY _____ STATE _____

Let us assume
full, undivided responsibility

TWENTY-TWO YEARS EXPERIENCE IN MANUFACTURING PRECISION HONING EQUIPMENT

MICROHONING MACHINES

MICROHONING FIXTURES

MICROHONING TOOLS

MICROHONING ABRASIVES

DEVELOPMENT-ENGINEERING

TECHNICAL SERVICE

The MICROMATIC HONE CORPORATION has been the principal manufacturer of honing equipment for the past twenty-two years. In that time we have designed and put into production thousands of honing installations. An active research and development program has always been maintained. This has resulted in the development of a new, more precise, production process—MICROHONING.

We have the most complete line of Microhoning machines, fixtures, tools (all designed and manufactured in our own plant) available anywhere. We stock and process honing stones manufactured by the three largest abrasive manufacturers in the country. This, plus a staff of Engineers and Service Technicians that have the greatest honing know-how of any organization in the world, warrants us asking that you LET US ASSUME FULL, UNDIVIDED RESPONSIBILITY FOR THE RESULTS OBTAINED WITH YOUR MICROHONING EQUIPMENT.

MICROMATIC HONE CORPORATION
8100 SCHOOLCRAFT AVENUE • DETROIT 4, MICHIGAN

District Field Offices: 1323 S. Santa Fe Avenue, Los Angeles 21, California • 206 S. Main Street, Rockford, Illinois • 231 S. Pendleton Avenue, Pendleton, Indiana • MICRO-MOLD Manufacturing Division, Boston Post Road, Guilford, Connecticut • 55 George Street, Brantford, Ontario, Canada

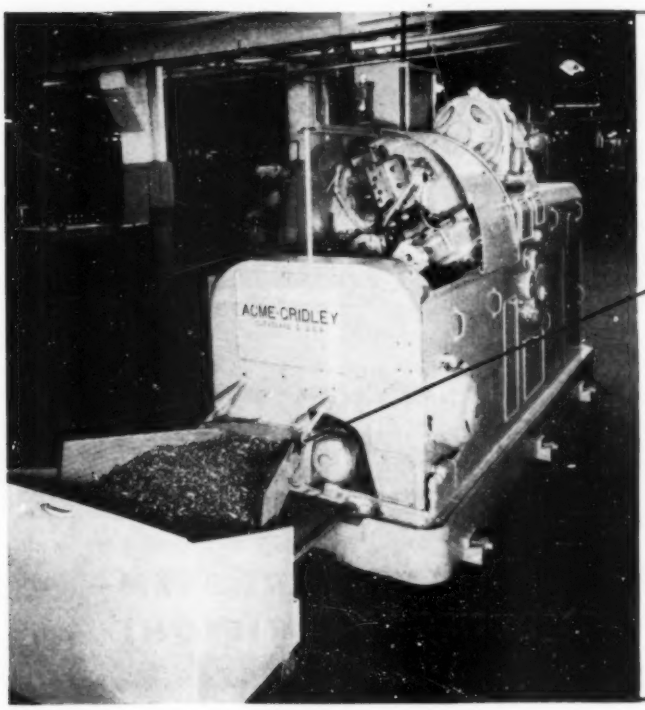
*Micromatic** MICROHONING

Write today for CROSS-HATCH describing the MICROHONING *process*

**Reg. U. S. Patent Office*

All Screw conveyors are not the same

LINK-BELT offers you the widest range to match your design needs



HELICOID CONVEYOR . . .

Trouble-free chip removal on this National-Acme high-speed automatic Model M Single Spindle Bar is provided by a Link-Belt Helicoid (Screw) Conveyor, shown above before assembly. The trough is tailor-made to fit the housing and hoppers of the screw machine, and the drive is located at the discharge end for convenience of inspection and lubrication.

Helicoid and Sectional Conveyor Screws, mounted or unmounted, are available for general application; may be furnished in the metal best suited to your purpose, with components selected from the most complete line."

MORE than capacity . . . more than length . . . are considered by Link-Belt engineers when they recommend screw conveyor for your machines. Abrasiveness, moisture content, size of feed, corrosiveness and many other factors are vitally important.

Remember, Link-Belt is the nation's top producer of materials handling and power transmission equipment . . . another reason why Link-Belt Screw Conveyors are simple, compact, have few wearing parts, greater dependability. Then too . . . They're accurately made to insure easy assembly and smooth operation.

Link-Belt Screw Conveyors are made in both continuous and sectional flight types — mounted and unmounted. Our engineers will be glad to give you the complete story.

LINK-BELT

SCREW CONVEYORS

LINK-BELT COMPANY: Chicago 8, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices in principal cities.

450 to 1000 Feet of Track Maintained Per Hour!

Powerful TDA BRAKES

PROVIDE SAFE, EFFECTIVE CONTROL!

Railway track maintenance has to be quick, safe and positive. And the Pullman-Standard power track maintenance machines can crib, clean ballast, and tamp almost as many ties in an hour as a multiple-power-tool hand tamping gang can do in a day! These fast working machines need dependable brakes to stop and hold them in exact but continually changing work positions. And they have them! They're equipped with sturdy, TDA "P" Series Power Brakes. The simple design of these efficient brakes provides positive action—easy, low-cost maintenance.

WHATEVER *YOUR* BRAKING PROBLEM— TAKE IT TO TDA BRAKE DIVISION!

Modern industry is constantly working to produce machines that operate faster, safer and with greater efficiency. In many of these machines *controlled rotation* plays an important role. That's why TDA Brake Division is putting its 40 years' experience to good use in developing better, more efficient brakes to meet any type of industrial application. A staff of skilled brake engineers and TDA's modern production facilities stand ready to help you solve your specific braking problem. If one of a complete line of dependable TDA Brakes doesn't do the job, TDA Brake Division will design a brake to fit your needs. Simply mail the coupon below for complete information.

Here Are A Few Of The Many Products Which Can Be Equipped With TDA Brakes

Centrifuges • Compressors • Conveyors • Cranes Cream separators • Diesel hook-ups • Dry cleaning machinery • Extractors • Hoists • Industrial electric trucks • Lathes (automatic) • Looms (textile) • Lumber mill machinery • Machine tools • Materials handling equipment • Motors • Packaging machinery • Paint mixers • Press brakes • Printing presses • Rolling mills • Shears • Warpers (textile) • Welding positioners • Winches • Automotive • Farm equipment Earth moving equipment • Construction equipment Public transportation

IF IT ROTATES WE CAN BRAKE IT

TDA BRAKE DIVISION—DEPT. A-6
ASHTABULA, OHIO

Please mail brake information on these applications:

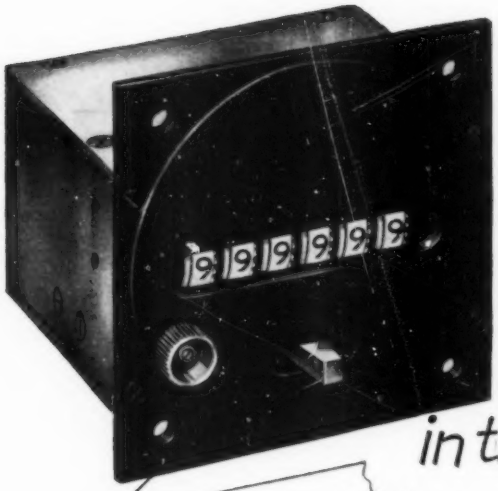
NAME _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____

TIMKEN Detroit BRAKES
TDA BRAKE DIVISION
THE TIMKEN-DETROIT AXLE COMPANY
ASHTABULA, OHIO.
Accepted TDA Standard
TRADE MARK REGISTERED



...and here's a Counter that talks to Jet-Testers in their own language...

Added Evidence that—

Everyone Can Count on VEEDER-ROOT

This technician is reading an electrically operated counter, used to record data in test instruments that check aircraft performance.

And this counter is one of innumerable Veeder-Root specials now on duty in every arm of the service. If you can use such counters (or need counters of special design) on D-O—rated orders, then you can count on Veeder-Root to help you with all possible dispatch.

VEEDER-ROOT INCORPORATED
"The Name That Counts"
HARTFORD 2, CONN. • GREENVILLE, S.C.
Montreal 2, Canada • Dundee, Scotland
Offices and agents in principal cities

VEEDER-ROOT COUNTERS *"Count Everything on Earth"*

DO NOT
LUBRICATE
Life-Line motor
PAIRED FOR PRODUCTION
Life-Linestarter

Exposed?

These two retard corrosion's bite

Splashing liquids, outdoor service, chemical fumes. You'd have to look a long time to find a motor and starter that take this kind of corrosive service as well as the matched Life-Line chemical motor and Life-Linestarter®.

The special enclosures of Life-Linestarters are extra protected to ward off corrosion. Castings are sprayed with iron-oxide, zinc-chromate primer; then, finished with aluminum lacquer. A neoprene gasket between covers seals out corrosive elements.

Inside, too, parts are extra protected. All steels are cadmium plated . . . contacts are pure silver . . . coil laminations, treated with protective film, then double coated with aluminum paint. These kinds of extras have made the Life-Linestarter outstanding for chemical service.

The Life-Line chemical motor has also proved itself best for chemical service, for more than one reason. Bonderized® steel frame and brackets don't give corrosion a chance . . . have outlasted conventional motors. Sealed bearings guard against acid, dirt, moisture. Windings, extra protected by multiple layers of Thermoset varnish, stand up to extreme corrosive conditions. Enclosures, too, make sure vital parts are fully protected.

This extra protection . . . this extra life you get with Life-Line motors and Life-Linestarters is available to you at *no extra cost.* Simply specify Life-Line motors and Life-Linestarters on your next job. Ask your Westinghouse representative for complete information on this production team. He has the answers. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21627

YOU CAN BE SURE... IF IT'S Westinghouse

Life-Line

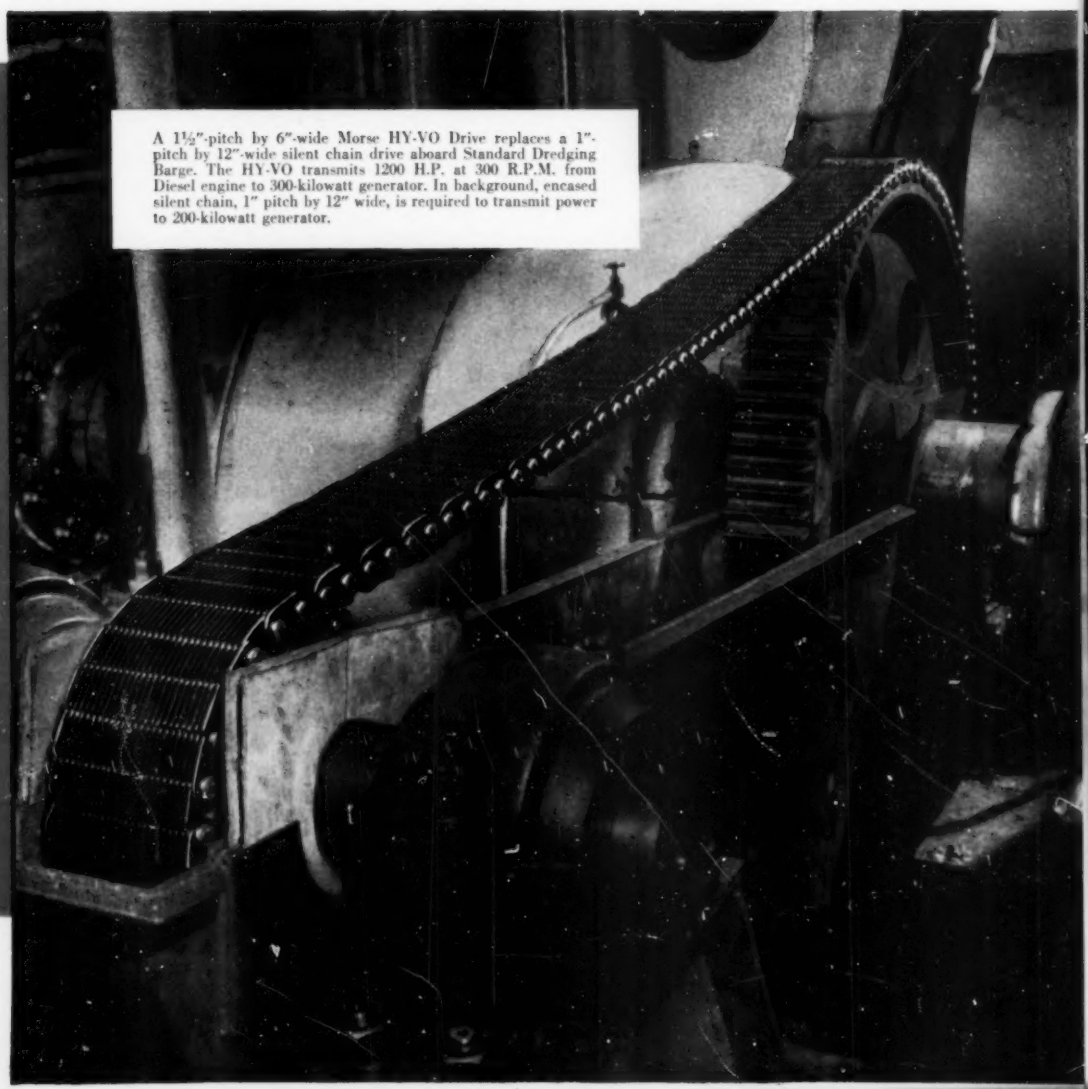
MOTORS and CONTROLS

Now—
more than ever

M=PT

Morse means
Power
Transmission

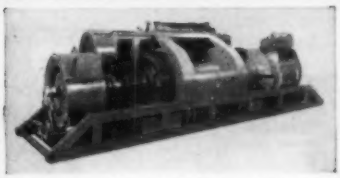
Sensational, new transmits up to



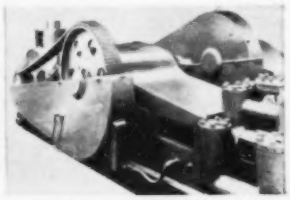
A 1½"-pitch by 6"-wide Morse HY-VO Drive replaces a 1"-pitch by 12"-wide silent chain drive aboard Standard Dredging Barge. The HY-VO transmits 1200 H.P. at 300 R.P.M. from Diesel engine to 300-kilowatt generator. In background, encased silent chain, 1" pitch by 12" wide, is required to transmit power to 200-kilowatt generator.

Morse HY-VO Drive

5000 hp at 1200 rpm!



Designers said it couldn't be done. But Morse HY-VO Drives of just 2" pitch by 12" width transmit 1500 H.P. at 600 R.P.M. in this *portable* Emsco oil field drawworks.



Emsco mud pumps, used in conjunction with drawworks above, have 1½"-pitch by 8"-wide Morse HY-VO Drives transmitting 765 H.P. at 1120 R.P.M.

A 1½"-pitch by 3"-wide HY-VO Drive on irrigation pump of Joe Summers & Co. in Mission, Texas, transmits 300 H.P. at 514 R.P.M., *with chain velocity of 4600 F.P.M.*, continuously during irrigation season.

Velocities up to 6500 F.P.M.!

The sensational new Morse HY-VO Drive transmits more horsepower at higher speeds and lower cost than any other type of drive. It combines for the first time the strength and positive action of a gear, the smoothness and flexibility of a belt with the efficiency of a chain.

A far narrower HY-VO Drive can operate at vastly increased speeds—at top efficiency, in less space, with reduced heating and noise. The HY-VO can cut cost-per-hour of power transmission as much as 50%, and add up to one-third more service life.

The Morse HY-VO Drive opens the way for transmitting greater horsepower from smaller, more economical high-speed engines. (Case histories here show you some of the amazing accomplishments of HY-VO Drives.)

For more complete HY-VO Drive information, write for Catalog No. C 72-51 today. (Orders for HY-VO Drives must carry priority rating at present time.)

MORSE CHAIN COMPANY
Dept. 202, 7601 Central Ave.
Detroit 8, Michigan

MORSE
MECHANICAL
POWER TRANSMISSION
PRODUCTS

PRODUCTS OF BW BORG-WARNER

Operation of WARNER & SWASEY made safer, more automatic

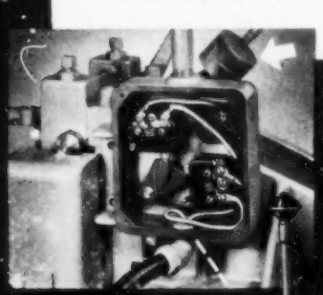
WARNER & SWASEY, Cleveland, manufacturers of machine tools and textile machinery, have used MICRO precision snap-action switches for many years as a "principle of good design."

In the Converter—a machine which cuts synthetic fibers, blends them with wool, or with other synthetic fibers to form crimped "sliver," ready for further processing—successful operation demands sensitive control at the delivery end by extremely accurate and dependable precision switches.

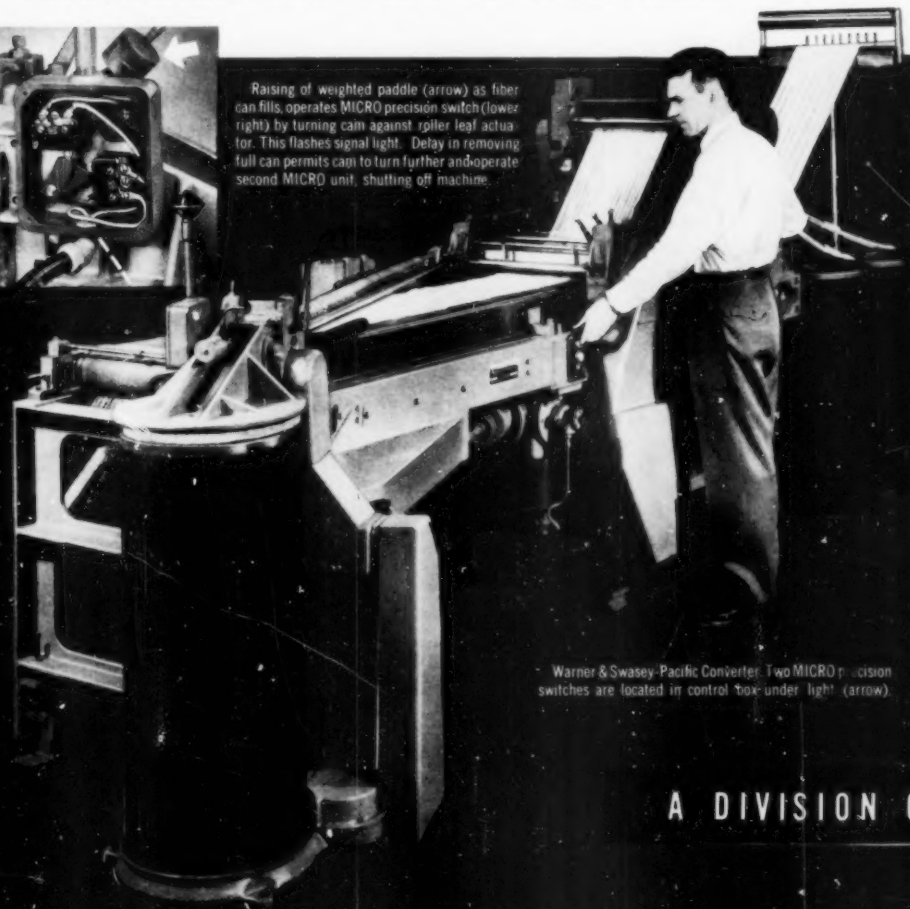
Extreme sensitivity, small travel and accurate trip point of MICRO precision switches were important factors in their selection by Warner & Swasey engineers. Long life and trouble-free operation . . . universally acknowledged MICRO characteristics . . . were also prime considerations.

In another Warner & Swasey textile machine—the Pin Drafter—the use of a MICRO sealed switch makes it impossible to operate the machine unless the belt drive is covered.

These uses of MICRO products by Warner & Swasey are typical of the many ways in which design engineers in every phase of industry have come to rely on MICRO SWITCH for precision switching components to meet unusual and exacting requirements.



Raising of weighted paddle (arrow) as fiber can fills, operates MICRO precision switch (lower right) by turning cam against roller leaf actuator. This flashes signal light. Delay in removing full can permits cam to turn further and operate second MICRO unit, shutting off machine.



Warner & Swasey-Pacific Converter. Two MICRO precision switches are located in control box under light (arrow).

A DIVISION OF

Textile Machines with MICRO Precision Switches

MICRO "W22" Precision Switches provide automatic control of operation of Warner & Swasey-Pacific Converter

The MICRO "W22" roller lever actuated switch used in the Warner & Swasey application combines compact design, low operating force and the ability to be operated by cams or other moving devices.

The actuator is a pivoted short lever of steel with roller assembly attached. An auxiliary coil spring, assembled under the lever, improves the resistance of the switch to vibration.

As in all MICRO basic switch designs, circuit arrangements, terminals and other characteristics can be provided to meet the exact requirements of the individual application. This versatility has already provided almost 5000 variations of MICRO precision switches to meet specific design needs.

If your problem involves precision snap-action switches, call or write the nearest MICRO SWITCH branch office.

MICRO sealed die cast precision switch (arrow) mounted on Warner & Swasey Pin Drafter. Unless cover is over belt drive, holding switch closed, the machine cannot be operated.

MICRO MS SWITCH

FREEPORT, ILLINOIS

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

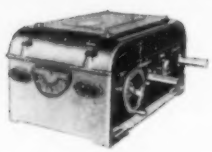
CAN the machines you are building today be changed over quickly and easily to defense work? Will they handle new sizes, shapes or different materials without dependence on highly skilled operators?

On any machine, REEVES Variable Speed Control means adaptability to more differ-

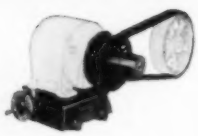
Reeves

speed control

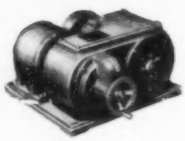
puts "change-over capacity" into machines that may be called on to perform extra duties



VARIABLE SPEED TRANSMISSION provides infinite, accurate speed flexibility over a wide range —2:1 to 16:1. Capacities to 87 hp.



VARI-SPEED MOTOR PULLEY converts any standard constant speed motor to variable speed drive. Speed variations to 4:1; sizes to 10 hp.

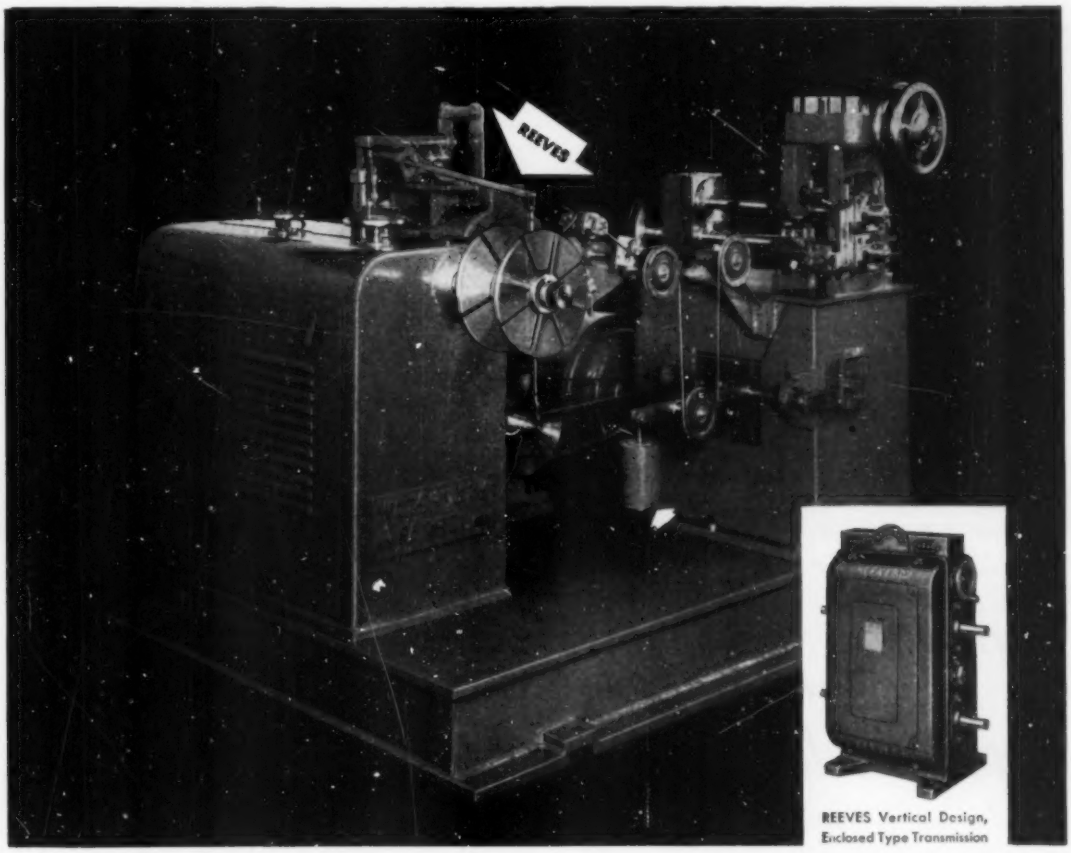


MOTODRIVE combines motor, speed varying mechanism and reduction gears in a single unit. Speed variations 2:1 to 10:1, inclusive. Sizes ¼ to 20 hp.

VARI-SPEED JR., a compact, low-cost unit for light machinery. Takes any standard V-belt. Ratios, 1¾:1 to 2¾:1. Sizes ⅛ through 1½ hp.

ent jobs—instantly adjusting to varying materials, conditions and operating skills. In brief, REEVES means greater versatility, more output of higher quality, less down-time on every machine.

Get and *know* the full facts on REEVES—the one complete line of variable speed drives with a wide variety of manual, electric or automatic controls. Make REEVES versatility standard on all of your machines. For a complete reference, write today for the comprehensive, 132-page REEVES catalog, No. K60a-3N . . . industry's "Speed Control Textbook."



REEVES Vertical Design, Enclosed Type Transmission

A wide range of wire sizes up to .06" diameter can be handled at speeds up to 1000 fpm on this REEVES-equipped Waterbury-Farrell wire flattening mill. Tension of wire is controlled automatically by a REEVES hydraulically controlled vertical type transmission. Proper tension for each size and kind of wire is pre-set by weights on floating roll. The floating roll actuates the highly sensitive REEVES hydraulic control to reduce winding speed and maintain constant tension as spool builds up. By adding or removing weights, the machine can be immediately and conveniently operated on other sizes and kinds of wire.

accurate · variable
REEVES Speed Control

REEVES PULLEY COMPANY, COLUMBUS, INDIANA

Recognized Leader in the Specialized Field of Speed Control Engineering

WHEN A PUMP MUST HANDLE
Widely Varying Heads

. . . the efficient, economical choice is a dependable Fairbanks-Morse Westco turbine type pump. These rugged, precision-built pumps are designed so that maximum capacity is obtained at an operating speed of 1750 r.p.m. when discharging at low pressure. High pressures are developed at the same speed with only a slight reduction in capacity.

Another important Westco advantage: you get multi-stage pump performance through the use of a single stage multi-vaned impeller.

These important Westco features make it a top choice where the pump must form an integral part of machines, units or systems. It is exceptionally compact. Capacities range from 1 to 200 g.p.m., with heads ranging up to 500 feet.

FAIRBANKS
A NAME WORTH

WHEN YOU NEED POSITIVE PUMPING OF ANY LIQUID
from Gasoline to Molasses

. . . the choice is Fairbanks-Morse Rotary Pumps. These positive displacement pumps efficiently handle any free-flowing liquid. Their exceptionally high efficiency, steady flow, freedom from vibration and non-fluctuating load characteristics assure long, economical service.

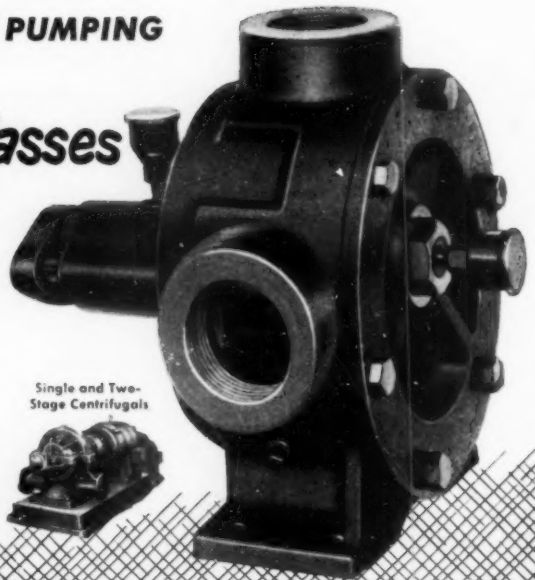
With only two moving parts, there are no complicated adjustment or service problems. Capacities range from 1.3 to 450 g.p.m.

Other FAIRBANKS-MORSE Pumps Include:

Builtogether Centrifugals

Side-Suction Centrifugals

Single and Two-Stage Centrifugals



WHEN A SCALE MUST DO

More than Weigh

. . . then Fairbanks-Morse Printomatic Weighers are your answer. In addition to automatically recording weights on a ticket or tape, these weighing instruments can, through the use of electronics, automatically control production and processing operations. They can be adapted for automatic control of batching processes, materials handling, and conveying systems. They can open and close gates or valves, controlling flow of material to predetermined quantities. Templets can be used to preserve formula secrets when compounding mixes.

Fairbanks-Morse Printomatic Weighers speed operations. They eliminate the chance for human errors . . . eliminate inefficiencies and losses caused by inaccuracies. Your Fairbanks-Morse weighing expert will be happy to help you fit a Printomatic to your operations.

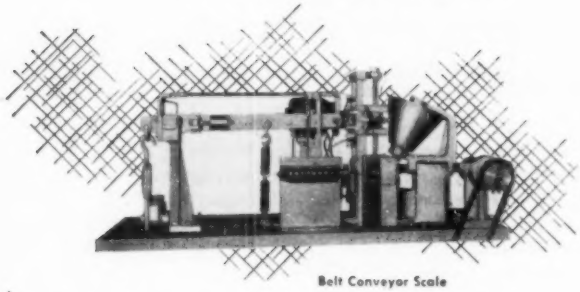
Printomatic Weigher

-MORSE

REMEMBERING

WHEN YOU MUST WEIGH

"On the Move"

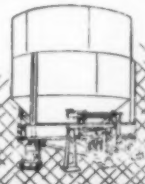


Belt Conveyor Scale

. . . check Fairbanks-Morse Belt Conveyor Scales. These efficient, accurate weighing instruments automatically weigh material in transit . . . provide cumulative totals up to 1500 tons per hour. Installed as an integral part of the conveyor system, Fairbanks-Morse Belt Conveyor Scales speed weighing of incoming raw bulk materials and materials in process.

Whatever your weighing requirement, there is a Fairbanks-Morse lastingly accurate scale that exactly suits your needs. Fairbanks-Morse Scales or *component scale parts* can be supplied to fit right into your equipment for weight or control operations.

Hopper Scale



See next page for Fairbanks-Morse Sales Centers

FOR PROTECTION

AGAINST DUST, DIRT, ABRASIVES, STEAM, FUMES, ETC.

New Fairbanks-Morse Type QZE, Frame 284 Motor. Also available in smaller frame sizes.

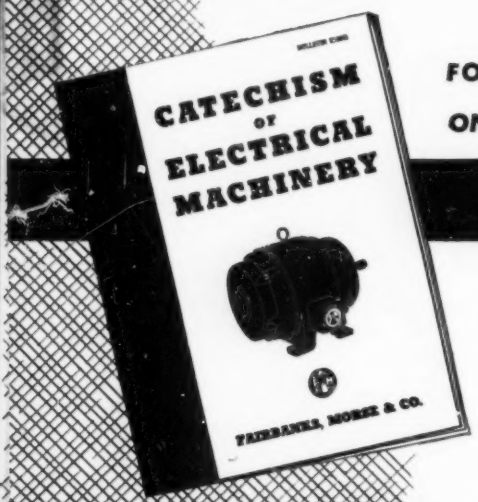
FAIRBANKS-MORSE

Totally Enclosed, Non-Ventilated Motors

For the toughest operating conditions, here is the newest development in totally enclosed, non-ventilated motors. Fairbanks-Morse Type QZE Motors are now available in Frame 284—delivering 7½ hp. at 1800 r.p.m., 5 hp. at 1200 r.p.m—filling a long-standing need for this type and size of motor. New features that assure cool, long-running service include a unique end-bell construction with cooling fins for efficient heat dissipation—and for safe, uniform, internal temperatures. For the full story on the new dependability this class of QZE Motors can bring to your most severe motor jobs, ask your Fairbanks-Morse motor representative or write Fairbanks, Morse & Co., 600 South Michigan Ave., Chicago 5, Illinois.

FAIRBANKS

A NAME WORTH



FOR INFORMATION

ON DESIGN AND USE OF ELECTRIC MOTORS

Send for This Manual!

In this popular "Catechism of Electrical Machinery," you'll find an invaluable fund of basic information on the design, performance and proper use of the common types of alternating and direct current motors and generators. Primarily intended for training those who are not too familiar with electrical phenomena or terminology, it has been widely accepted by engineers, designers, and others as an aid in instruction of new men. It can be especially useful now, during this period of expanding and shifting employee rolls. Write your nearest Fairbanks-Morse Sales Center for your copy.

FOR SATISFACTION

IN SERVICES THAT ARE ROUGH ON MOTORS!

Compare these features

Superior Electrical and Mechanical Construction In All Fairbanks-Morse Type QZE Motors

Completely Protected Windings — No ventilating openings: impossible for any foreign matter to come in contact with windings.

Easy to install — NEMA standard mountings, interchangeable with standard, open-type motors of same ratings.

Grease lubricated ball bearings — permit sealing for the life of the bearing if desired.

Heat transfer air circulation — continuous circulation of captive air inside frame structure assured by rotor fans.

Convenient lubrication — protective covers or other parts need not be removed.

Reversible recessed conduit box — symmetrical construction allows easy reversal of stator frame.

COPPERSPUN ROTOR an Added Advantage

All Fairbanks-Morse Type QZE totally enclosed, non-ventilated motors offer the Fairbanks-Morse Copperspun rotor whose one-piece, virtually indestructible design and excellent electrical characteristics assure longer, more trouble-free life.

-MORSE

REMEMBERING

THESE ARE YOUR FAIRBANKS-MORSE SALES CENTERS

ATLANTA 3, GEORGIA
760 Lee St., S. W.
AMhurst 7701

BALTIMORE 18, MD.
659 E. 25th St.
BElmont 5258

BIRMINGHAM 1, ALA.
626 N. Ninth St. Zone 4
3-6546

BOSTON 10, MASS.
178 Atlantic Avenue
LAfayette 3-3600

BUFFALO 3, N. Y.
33 Franklin St.
Lincoln 4210

CHARLOTTE 2, N. C.
Liberty Life Bldg.
Room 605
6-2893

CHICAGO 5, ILLINOIS
1550 S. State St.
HArrison 7-7100

CINCINNATI 2, OHIO
49 Central Avenue
MAin 3010

CLEVELAND 14, OHIO
3000 W. 117th St.
CLearwater 1-3300

COLUMBUS 8, OHIO
1034 Goodale Blvd.
WAlnut 8581

DALLAS 2, TEXAS
1713 N. Market Street
CEntral 4347

DENVER 2, COLO.
1500 17th Street
TAbor 6241

DES MOINES 17, IOWA
2017 Dean Avenue
6-1189

DETROIT 13, MICHIGAN
11110 East Warren Ave.
VAlley 1-7100

DULUTH 2, MINN.
Board of Trade Bldg.
2-7538

HOUSTON 13, TEXAS
5521 Navigation Blvd.
WAyside 2159—(LD 506)

INDIANAPOLIS 2, IND.
1499 N. Harding St.
FRanklin 3684
ATlantic 3092

JACKSONVILLE 6, FLA.
930 East Adams St.
5-6473

KANSAS CITY 7, MO.
1300 Liberty Street
VIctor 6474

LOS ANGELES 11, CALIF.
4535 S. Soto Street
JEfferson 8151

LOUISVILLE 8, KY.
2008 So. Brook St.
CAlhoun 1469

MEMPHIS 7, TENN.
676 Jefferson Ave.
5-1614

MILWAUKEE 3, WIS.
404 N. Plankinton
DAly 8-0180

MINNEAPOLIS 15, MINN.
417 S. Fourth Street
MAin 4353

NEW ORLEANS 13, LA.
1000 St. Charles Ave.
RAymond 3115

NEW YORK 4, N. Y.
80 Broad St.
HAnover 2-7470

OMAHA 8, NEBRASKA
902 Harney St.
ATlantic 3122

PHILADELPHIA 8, PA.
401 N. Broad St.
WA 2-4100

PITTSBURGH 24, PA.
4301 Main Street
SChenley 1-3123

PORTLAND 14, OREGON
105 S. E. Taylor St.
EAst 0131

PROVIDENCE 3, R. I.
187 Pine Street
GAspee 1-1531

ST. LOUIS 2, MO.
217 South Eighth St.
CHestnut 7483

ST. PAUL 1, MINN.
220-26 E. Fifth Street
GArfield 4325

SALT LAKE CITY 1, UTAH
153 W. Second South St.
3-2108 & 3-5139

SAN FRANCISCO 7, CALIF.
630 Third Street
EXbrook 2-5855

SEATTLE 99, WASH.
Salmon Bay Terminal
ALder 6600

STUTTGART, ARK.
403 South Main St.
185

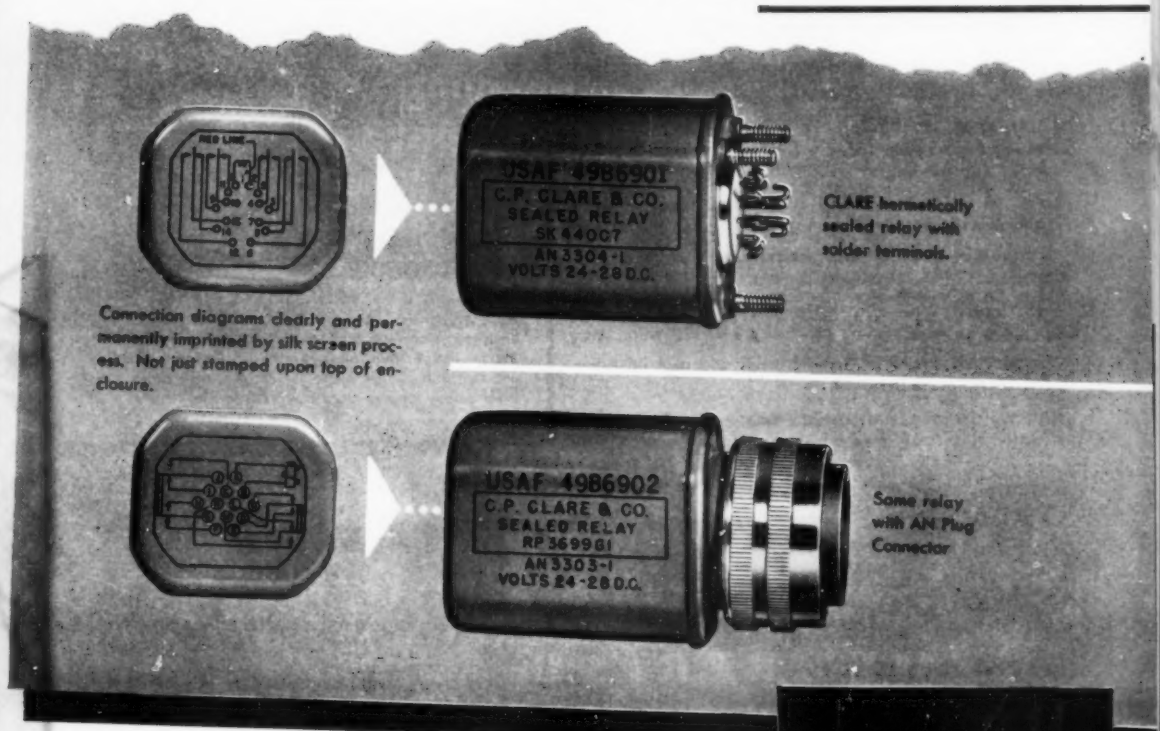
TULSA 3, OKLA.
1335 Hunt Bldg.
3-8231

WASHINGTON 5, D. C.
1000 Vermont Ave., N. W.
District 6694

FAIRBANKS-MORSE de MEXICO S. A.
Balderas 146, Mexico 1, D. F. Mexico
10 06 74 y 10 09 58

Export Division:
NEW YORK 4, N. Y.
80 Broad Street—HAnover 2-7470

Plus Values of CLARE when unfailing

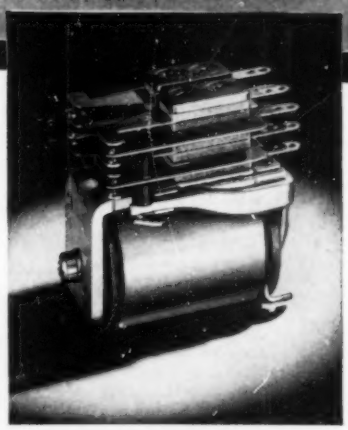

USAF 4986901
C.P. CLARE & CO.
SEALED RELAY
SK 44007
AN 3304-1
VOLTS 24-28 D.C.
CLARE hermetically sealed relay with solder terminals.
Connection diagrams clearly and permanently imprinted by silk screen process. Not just stamped upon top of enclosure.
USAF 4986902
C.P. CLARE & CO.
SEALED RELAY
RP 369961
AN 3303-1
VOLTS 24-28 D.C.
Same relay with AN Plug Connector

This small CLARE Type "R" Relay supplies many special features responsible for the outstanding performance of these new "AN" approved relays.

The operating "heart" of these two new hermetically sealed relays is the CLARE Type "R" Relay which is characterized by unusual sensitivity and extremely long life.

It combines the advantages of a telephone-type relay with the small size, light weight and resistance to vibration required to meet the rigid demands of aircraft service. The Type "R" retains in an improved form the reed armature suspension which discerning engineers have come to recognize as one of the subtler reasons for the superior performance of CLARE Type "K" relays.

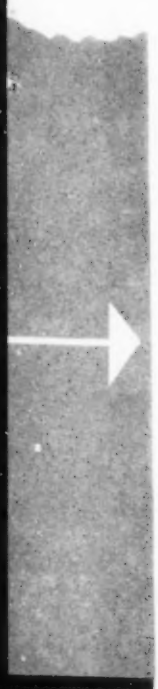
The Type "R" is $1\frac{7}{16}$" long, $1\frac{3}{64}$" high and 1" in width. It weighs approximately 2 ounces. Coil may be single or double-wound; armature, single or double-arm; operating voltage up to 230 volts d-c.



CLARE Type "R" RELAY

CLARE RELAYS . .

RELAYS make them 1st choice performance is a "must".



These two hermetically sealed CLARE RELAYS not only meet, but surpass, stringent requirements for airborne military use.

When the safety of a plane costing perhaps millions of dollars, and the priceless lives of its crew, may depend upon the unfailing performance of a relay, the *plus values* of a CLARE RELAY are of tremendous importance.

These two hermetically sealed CLARE Type "R" Relays were designed to meet airborne-service specifications so difficult and exacting that several months were required to run the rigid performance tests. They meet the specifications in every particular—and even *exceed* them in many significant respects!

The CLARE standard leak test, for example, made with a mass spectrometer, is much more stringent than the immersion test the relays are asked to meet. The resistance to vibration inherent in the design of the CLARE Type "R" Relay is an important factor in enabling these relays to exceed required specifications by a wide margin.

Outstanding Operational Features

- CLARE Type "R" Relay provides uncommonly wide contact gaps and heavy contact pressures without requiring any more operating power than ordinary relays of the same size.
- Powerful coil and generous use of iron in close-coupled magnetic structure enables these relays to pull in at 64% of nominal operating voltage at 85° C. and yet draw no more than 0.120 amp. on 28 volts at 25° C.
- Leakage: Terminal-to-terminal or terminal-to-frame resistance, 10,000 megohms.
- Cover is rolled and crimped over edge of base in a hydraulic press; does not depend on solder seam for mechanical strength.

Clare sales engineers are located in principal cities. Call on them or write: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials, Ltd.; Toronto 13. Cable Address: CLARELAY.

PAC

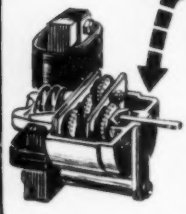
MISS

GES

SING

Do You Know?

FLOWERS BURST FROM SEED TO BLOOM IN SECONDS IN JOHN OTT'S TIME-LAPSE FILMS WHOSE PRECISE PERFORMANCE DEPENDS LARGELY ON **TELECHRON** TIMING MOTORS.



FROM 60 RPM TO ONE REVOLUTION PER 30 DAYS

IS THE RANGE OF TERMINAL SHAFT SPEEDS CONVERTED FROM THE 3600 RPM ROTOR SPEED OF STANDARD **TELECHRON** TIMING MOTORS AND INSTRUMENT MOVEMENTS.

THE HANDS OF A 16-FOOT TOWER CLOCK

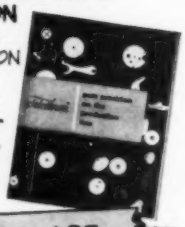
ARE OPERATED BY A **TELECHRON** C-TYPE SYNCHRONOUS MOTOR WEIGHING LESS THAN 2 POUNDS.

THIS FREE BULLETIN SIMPLIFIES SELECTION OF THE RIGHT MOTOR FOR THERMOSTATIC CONTROLS, VACUUM REGULATORS, STOKER CONTROLS, APPLIANCE TIMERS, AND MANY OTHER APPLICATIONS. CONTAINS CHARTS, TORQUE RATINGS, AND COMPLETE SPECIFICATIONS ON **TELECHRON** TIMING MOTORS. WRITE FOR BULLETIN IS-120 TODAY.

TELECHRON DEPARTMENT, GENERAL ELECTRIC COMPANY, 19 UNION STREET, ASHLAND, MASS.

SKILLED HELP ON "EMERGENCY" CONTRACTS

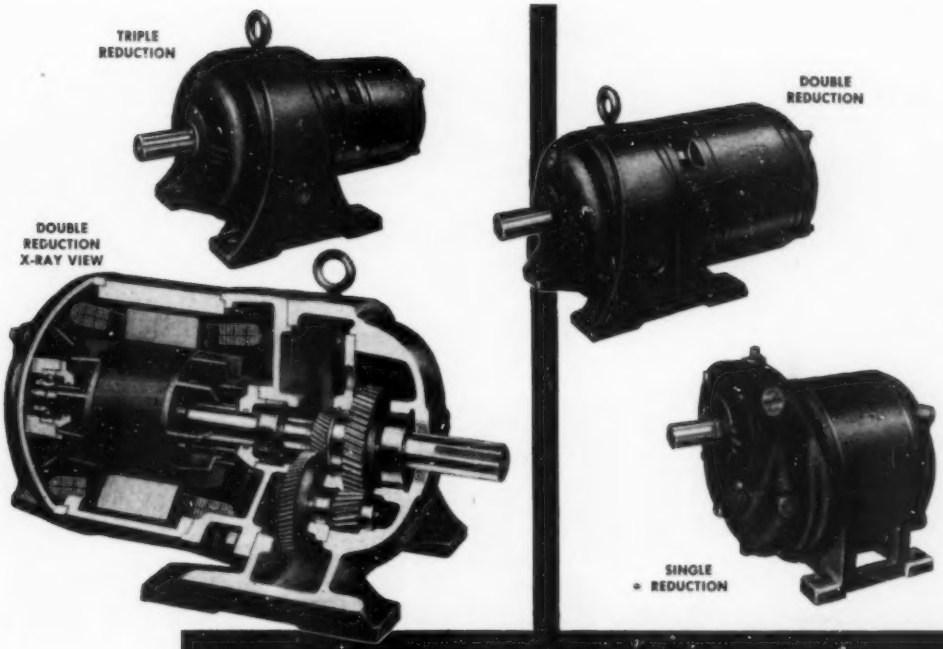
IS AVAILABLE AT **TELECHRON** PLANTS. NEW BROCHURE, "PRECISION ON THE PRODUCTION LINE", GIVES A QUICK PICTURE OF PERSONNEL CAPABILITIES AND MASS-PRODUCTION FACILITIES. WRITE FOR YOUR COPY TODAY.



Telechron®

ALL TELECHRON TIMING MOTORS ARE

INSTANTLY...CONSTANTLY SYNCHRONOUS



FOOTE BROS.-LOUIS ALLIS GEARMOTORS

PROMPT DELIVERY!

Would prompt delivery of Gearmotors solve your problem?

If you're up against costly delay, then keep in mind that you can count on prompt delivery of Foote Bros.-Louis Allis Gearmotors.

Foote Bros. offer the finest Gearmotor obtainable. A Gearmotor of superior design and construction—produced jointly by Foote Bros. and Louis Allis—both leaders in their respective fields.

Foote Bros.-Louis Allis Gearmotors are available in single, double and triple reductions to provide output speeds of 780 down to 7.5 r.p.m. Capacities from 1 h.p. through 150 h.p. Open drip-proof, splash-proof, enclosed and explosion-proof motors.

Mail the coupon for Bulletin GMA.

FOOTE BROS.
GEAR AND MACHINE CORPORATION
Dept W, 4545 South Western Blvd., Chicago 9, Ill.

- **Duti-Rated Gears—file hard tooth surfaces—resilient cores.**
- **Tang driven motor shaft pinion positively positioned.**
- **Extra capacity ball or tapered roller bearings.**
- **Cast iron housing for maximum rigidity under load. Large oil reservoir, splash lubrication.**
- **Leakproof oil seals.**
- **Dynamically balanced die-cast aluminum rotor. Impregnated windings assure protection from moisture, dust, and oil.**
- **Ball bearing motor for trouble-free operation.**

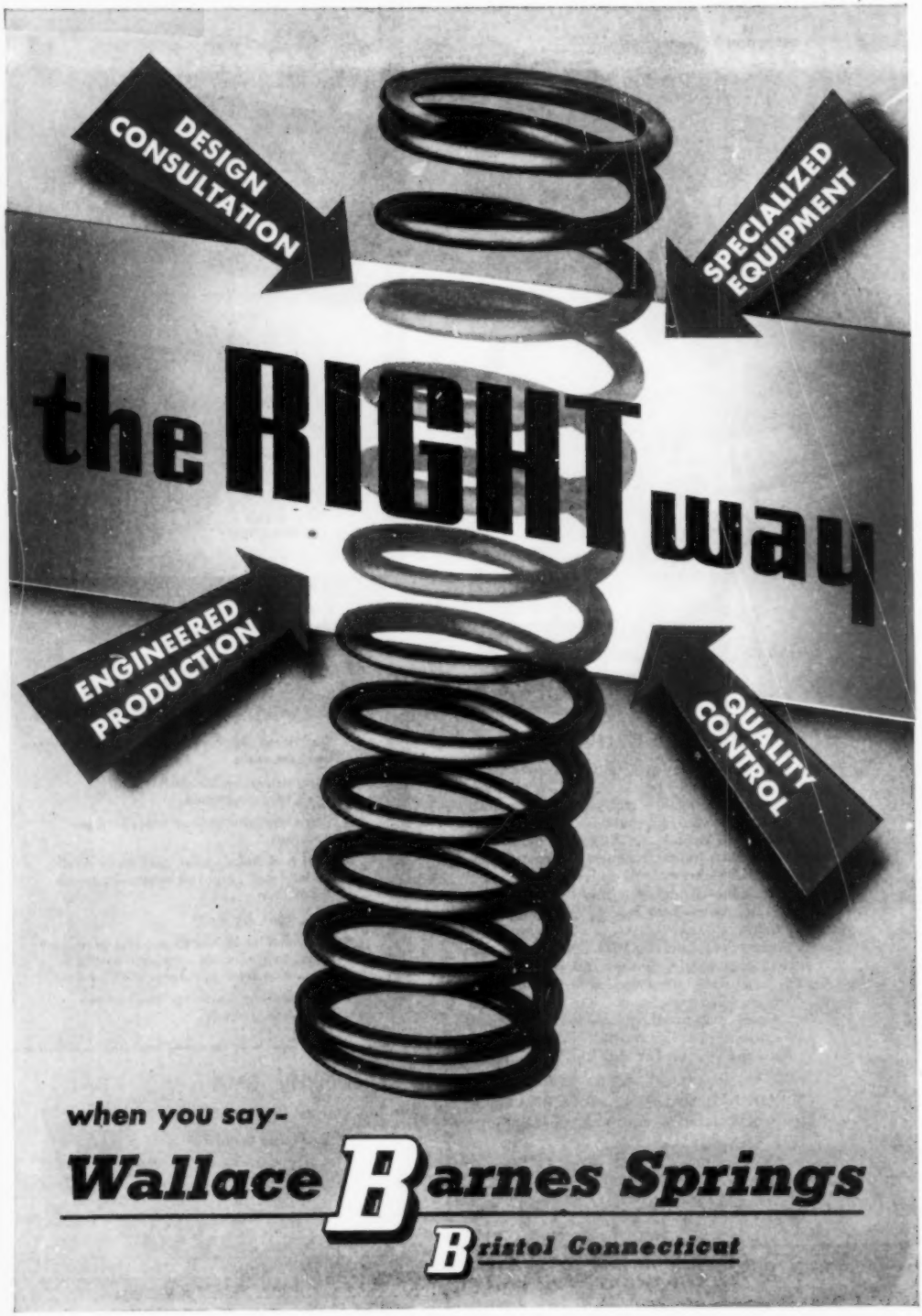
FOOTE BROS.
Better Power Transmission Through Better Gears

Write for Bulletin GMA

Foote Bros. Gear and Machine Corporation
Dept. W, 4545 So. Western Blvd.
Chicago 9, Ill.

Send me Bulletin GMA on Foote Bros.-Louis Allis Gearmotors.

Name.....
Company.....
Position.....
Company Address.....
City..... *Zone*..... *State*.....


DESIGN CONSULTATION
SPECIALIZED EQUIPMENT
the RIGHT way
ENGINEERED PRODUCTION
QUALITY CONTROL
when you say-
Wallace Barnes Springs
Bristol Connecticut

Speed reduction problem?

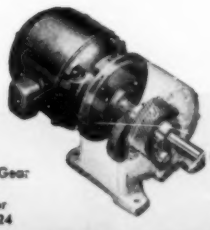
Is it Ratio? Space? Shock? Overload?

No *one* speed reducer solves *every* reduction problem. That's Why LINK-BELT Builds All THREE.

FOR the *right* speed reducer engineered to match your exact conditions, your best bet is Link-Belt. Link-Belt builds all three—Helical, Herringbone and Worm Gear Drives. When a Link-Belt power transmission engineer analyzes your problem, he isn't tempted to fit his recommendation to a limited line.

You can also be sure that the Link-Belt unit recommended is engineered and built for tough operating conditions. And efficiency in power transmission is matched by flexibility in application!

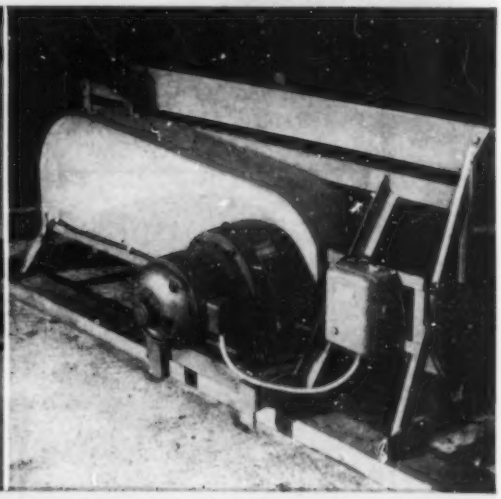
On Worm Gear Drives write for Book 2324



On Gearmotor and Helical Gear Drives write for Book 2247

On Herringbone Gear Drives write for book 2419

Link-Belt 1 hp Gearmotor, conveniently mounted, operates a revolving plate disc used in manufacturing tin cans. Note also Link-Belt Roller Chain and Roller Bearing Flanged Block.



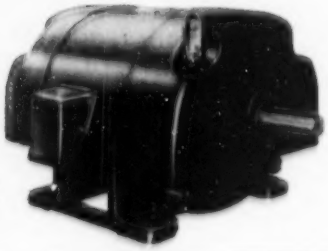
Conveyor section of a railroad tie doweling machine driven by a compact Link-Belt 2 hp Gearmotor through an enclosed Link-Belt Precision Steel Roller Chain Drive.

LINK-BELT
ENCLOSED GEAR DRIVES

12,560-A

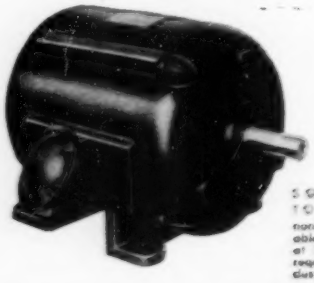
LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in Principal Cities.

The RIGHT motor



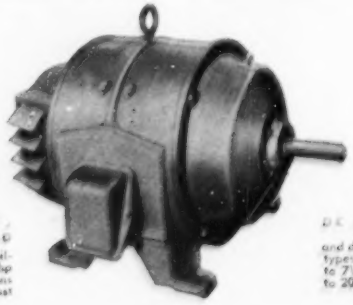
SQUIRREL-CAGE SPLASHPROOF

Form 8A. Has corrosion resistant covers which prevent entrance of splashing liquids.



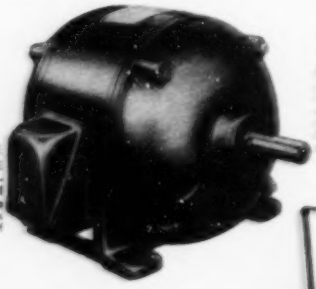
SQUIRREL-CAGE, TOTALLY-ENCLOSED

non-ventilated Form 8E. Available up to and including 3 hp at 1800 rpm, for applications requiring protection against dust, fumes, moisture



DC DRIPPROOF

and dripproof-protected types Form F. In ratings to 7½ hp. Form H. 10 to 200 hp.

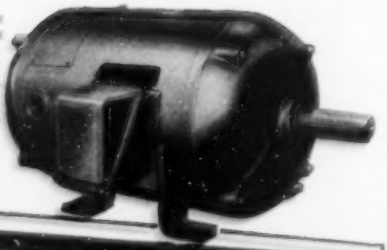


SQUIRREL-CAGE PROTECTED TYPE

Form 8A. An open dripproof motor for general purpose use. Available in wide modifications to meet a variety of conditions.

WOUND-ROTOR PROTECTED TYPE

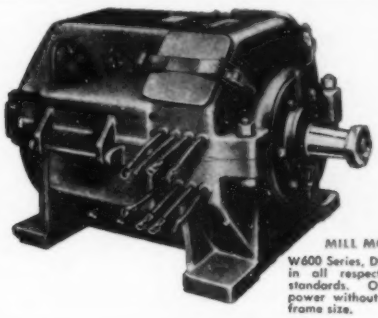
Form 8W. For slow, smooth acceleration, high starting torque with low starting current, or variable speed. Drip-proof, splashproof, 1 to 200 hp.



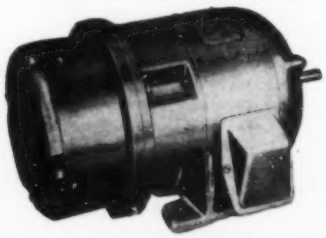
ELLIOTT COMPANY

does the job better!

"SEALEDPOWER" totally-enclosed fan-cooled squirrel-cage motors, 3 to 125 hp. Also explosion-proof underwriter's-approved, 20 to 125 hp. Cooled by air blown along the finned outer case.



MILL MOTOR, W600 Series, DC. Conforms in all respects to AISE standards. Offers more power without increase in frame size.



BRAKE MOTOR using latest disk type brake mounted on BA dripproof motor. Also available with totally enclosed and splashproof enclosures for AC or DC applications.

Take your pick of these ELLIOTT CROCKER-WHEELER INTEGRAL MOTORS

from 1 to 200 hp

■ NAME YOUR POISON—is it dust, dirt, corrosive fumes, explosive hazard, water in fog, in drops, in a deluge—is it heavy duty, normal duty, limited motor space, high starting torque, etc., etc. Whatever the condition, an Elliott Crocker-Wheeler motor will prove itself the *right* one for the job—*right* not only because it is designed for the conditions of your drive, but also because it has behind it names that for many years have meant quality motor performance.

GET FULL INFORMATION about the C-W motor you need. Tell us your drive problems and we will be glad to send informative bulletins on the motors indicated.

NEED LARGER MOTORS? Looking for a really big motor—big in quality as well as capacity? You'll find it in the Elliott "Fabri-Steel" line, which employs the modern technique of electric welding in the achieving of greater strength, rigidity, lightness, and adaptability, with long life and easy maintenance. Bulletin on request.

Address Your Request for Bulletin to
Dept. F, ELLIOTT COMPANY, JEANNETTE, PA.

CW-22

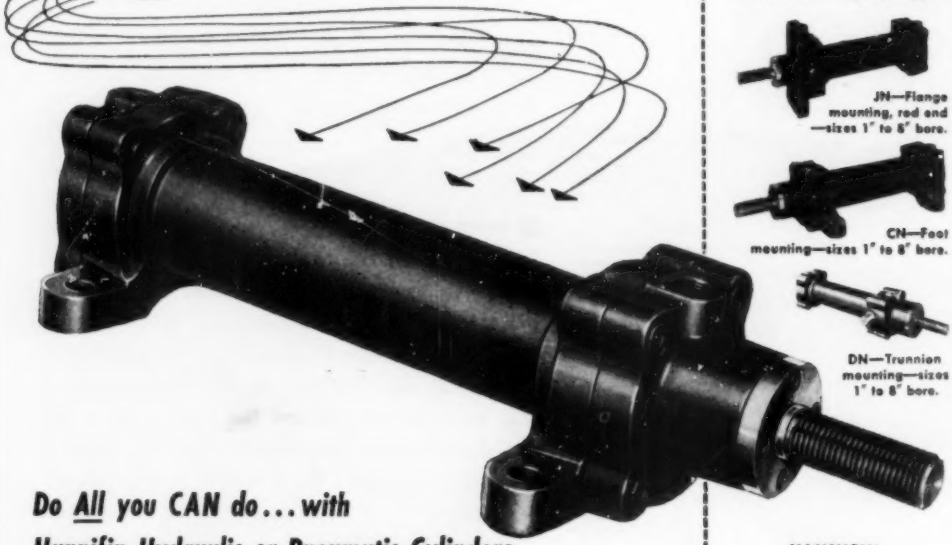
CROCKER-WHEELER DIVISION
AMPERE, N. J.

BRANCH OFFICES AND REPRESENTATIVES IN PRINCIPAL CITIES
ELLIOTT *Approved* SERVICE SHOPS COVER THE COUNTRY

1901 1951

Q: But we've always done this job mechanically. Why should we change to hydraulic or pneumatic cylinders?

A: You can save time, reduce physical effort, cut operating costs! We know, because our experience includes a number of jobs just like yours where cylinders were the answer.



Do All you CAN do... with Hannifin Hydraulic or Pneumatic Cylinders

If you want to **PUSH • PULL • LIFT • PRESS • CLAMP • SQUEEZE** . . . let Hannifin cylinders do the work! There are almost unlimited ways in which cylinders can be used to operate work-saving devices.

And, the Hannifin line of hydraulic and pneumatic cylinders includes the widest variety of standard mounting combinations, to enable you to get the cylinder that meets your needs—exactly!

A Suggestion: Call a Hannifin field engineer, or write for recommendations you can use—PROFITABLY!

Hannifin Corporation, 1125 S. Kilbourn Ave., Chicago 24, Ill.

Field Engineers in All Leading Industrial Centers

IN HYDRAULIC CYLINDERS ALONE, Hannifin builds 11 standard mounting styles, offering remarkable adaptability to a wide range of applications. An infinite number of custom cylinder designs are available. However, special cylinder problems are frequently solved with over 50 "combination mountings" made up of standard parts. *Ask for Bulletin 110.*

Here are 3 Popular Types

JN—Flange mounting, rod end —sizes 1" to 8" bore.

CN—Foot mounting—sizes 1" to 8" bore.

DN—Trunnion mounting—sizes 1" to 8" bore.

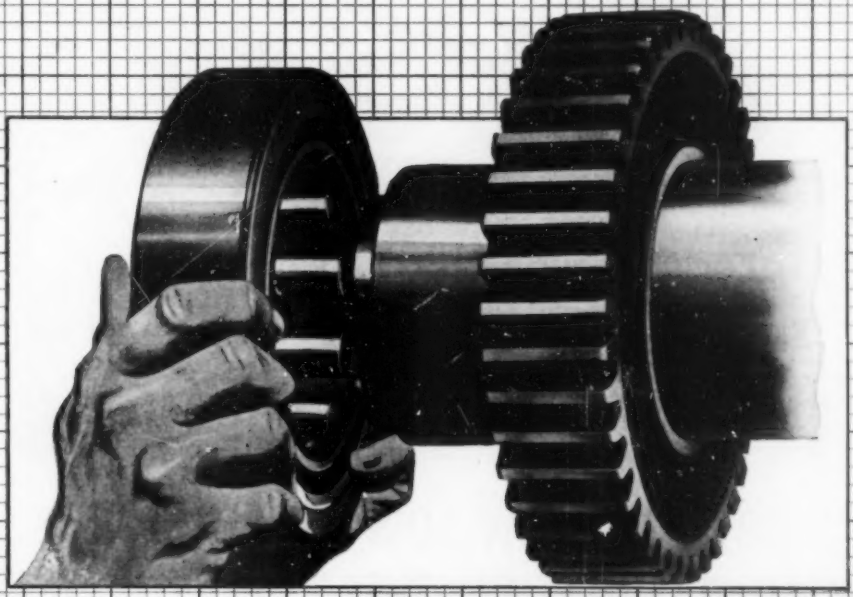
HANNIFIN ENGINEERING SERVICE

Opportunities to improve operations and cut costs through the proper use of hydraulic and pneumatic equipment are numerous. For these reasons, Hannifin maintains a full staff of experienced engineers to help you find the right answer. ASK FOR THEIR SUGGESTIONS.

HANNIFIN

Air Cylinders • Hydraulic Cylinders • Hydraulic Presses

Pneumatic Presses • Hydraulic Riveters • Air Control Valves



Simplify Shaft Design With HYATT HY-LOADS

The simplest way to mount an inner race on a shaft is by a press fit. Hyatt Hy-Load Roller Bearing inner races are made from carburizing type steels, heat treated to provide tough and ductile cores which safely permit relatively heavy fits. This fit is sufficient to hold the race in place without the use of accessory holding means, such as snap rings, lock nuts, or keys, and permits more simple and economical shaft design and construction. The press fit also locates the race properly and avoids the hazard of cocking or eccentricity which may occur with a loosely fitting race clamped endwise.

The holding of races on rotating shafts without auxiliary devices is just one of the features of Hyatt Hy-Load Roller Bearings. For complete information write for catalog 547. We'll be glad to send one to you. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

FIRST!

Federal was FIRST to develop...

FIRST to receive military approval of

RG TYPE CABLES

WITH THE NEW LOW-TEMPERATURE NON-CONTAMINATING THERMOPLASTIC JACKET

THESE ARE THE TYPES APPROVED TO DATE—

RG-5B/U	RG-21A/U
RG-6A/U	RG-22B/U
RG-8A/U	RG-58B/U
RG-9B/U	RG-58C/U
RG-10A/U	RG-59A/U
RG-11A/U	RG-62A/U
RG-12A/U	RG-63B/U
RG-13A/U	RG-65A/U

RG-79B/U

The following types—over ½-inch diameter—are available, subject to military approval:

RG-14A/U	RG-20A/U
RG-17A/U	RG-23A/U
RG-18A/U	RG-34A/U
RG-19A/U	RG-74A/U

Review your requirements now—to insure prompt delivery

Millions of feet of this special approved type have been produced by Federal—

AMERICA'S *pioneer* source of supply for low-temperature RG types—*that's Federal!* It was Federal that *first* successfully developed this type... *first* received approval of the U. S. Signal Corps and the U. S. Air Force... *first* manufactured it in enormous quantities!

That's why it pays to specify Federal when you need RG types. With Federal quality you get an extra measure of experience and know-how... experience that assures complete product satisfaction and dependable cable performance.

In addition to being a primary source of the listed RG types, Federal now is ready to supply complete coaxial cable assemblies... to meet your requirements.

For further details on assemblies and present and subsequent RG approvals, write to Dept. D-642.

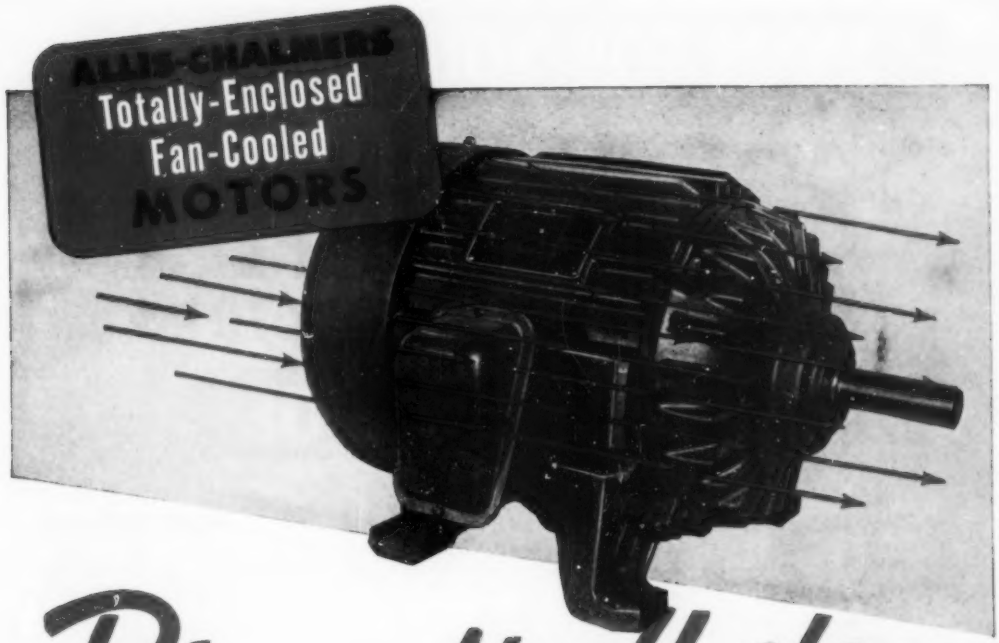
Manufacturer of America's most complete line of solid dielectric cables

FEDERAL TELECOMMUNICATION LABORATORIES, Nutley, N. J. ... a unit of IT&T's world wide research and engineering organization.

Federal Telephone and Radio Corporation

SELENIUM-INTELIN DIVISION—100 KINGSLAND ROAD, CLIFTON, NEW JERSEY

In Canada: Federal Electric Manufacturing Company, Ltd., Montreal, P. Q.
Export Distributors: International Standard Electric Corp., 67 Broad St., N.Y.



Blows itself clean as a Whistle!

DIRT IS CARRIED AWAY by cooling air blown over the ribbed cast iron frame and bearing housings of this new Allis-Chalmers tefc motor. That means less motor cleaning . . . inspection . . . overhaul!

Concealed air passages and pockets have been eliminated. Dirt can't build up to cause overheating. And as for oily dirt that sticks — just wipe or blow it off.

Studies show that on most applications, totally-enclosed fan-cooled motors more than pay back their extra cost in reduced maintenance. And this new Allis-Chalmers Type APZ tefc motor makes maintenance costs lower than ever before.

Rigid Construction

The frame is cast iron which has high resistance against corrosion and distortion. Bearings are pre-lubricated at the factory and should need no attention for years. Tapped holes with pipe plugs to permit regreasing and to provide grease relief are standard equipment.

Get All The Facts

The new Allis-Chalmers Type APZ totally-enclosed fan-cooled motor is built in all NEMA standard frame sizes from 224* to 505. Also in explosion-proof type. Your A-C Authorized Distributor or District Office has complete information. Call today, or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 51B7225.

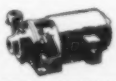
A-3427

Sold . . .
Applied . . .
Serviced . . .

by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

TEXROPE — Belts in all sizes and sections, standard and Vari-Pitch sheaves, speed changers.



PUMPS — Integral motor and coupled types from ⅝ in. to 72 in. discharge and up.

Texrope and Vari-Pitch are Allis-Chalmers trademarks.

ALLIS-CHALMERS

*Similar design non-ventilated motors Type APK, also available in frames 203 to 224 inclusive.

MORE FOR YOUR MONEY

WITH BENDIX SCINFLEX ELECTRICAL CONNECTORS

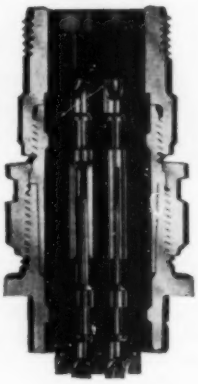
MOISTURE PROOF

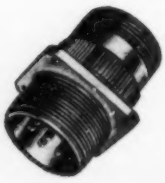
PLUS

- Pressure Tight
- Radio Quiet
- Single-piece Inserts
- Vibration-proof
- Light Weight
- High Insulation Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required

The importance of a completely moisture-proof electrical connector can scarcely be exaggerated. But in addition to this important characteristic, there are a host of other exclusive features that make Bendix Scinflex connectors outstanding for dependable performance. For example, the use of Scinflex dielectric material, an exclusive Bendix development of outstanding stability, increases resistance to flash over and creepage. In temperature extremes, from —67°F. to +275°F. performance is remarkable. Dielectric strength is never less than 300 volts per mil. If you want more for your money in electrical connectors, be sure to specify Bendix Scinflex. Our sales department will be glad to furnish complete information on request.

PLUS





SHELL
High strength aluminum alloy . . . High resistance to corrosion . . . with surface finish.

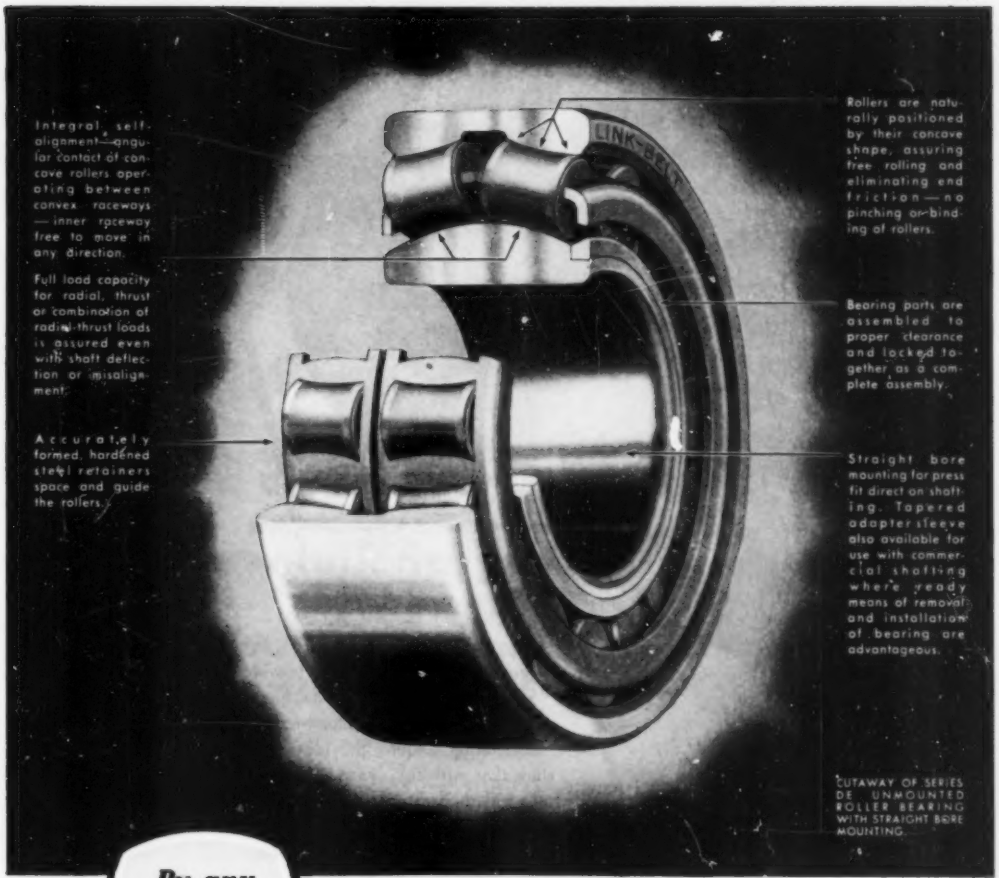
CONTACTS
High current capacity . . . Low voltage drop.

SCINFLEX ONE-PIECE INSERT
High dielectric strength . . . High insulation resistance.

Bendix

SCINTILLA MAGNETO DIVISION OF

LINK-BELT Ball and Roller Bearings smooth the path of power


Integral self-alignment—angular contact of concave rollers operating between convex raceways—inner raceway free to move in any direction.
Full load capacity for radial, thrust or combination of radial-thrust loads is assured even with shaft deflection or misalignment.
Accurately formed, hardened steel retainers space and guide the rollers.
Rollers are naturally positioned by their concave shape, assuring free rolling and eliminating end friction—no pinching or binding of rollers.
Bearing parts are assembled to proper clearance and locked together as a complete assembly.
Straight bore mounting for press fit direct on shafting. Tapered adapter sleeve also available for use with commercial shafting where ready means of removal and installation of bearing are advantageous.
LINK-BELT
CUTAWAY OF SERIES DE UNMOUNTED ROLLER BEARING WITH STRAIGHT BORE MOUNTING.

By any standard . . . **LINK-BELT Roller Bearings always assure anti-friction alignment**

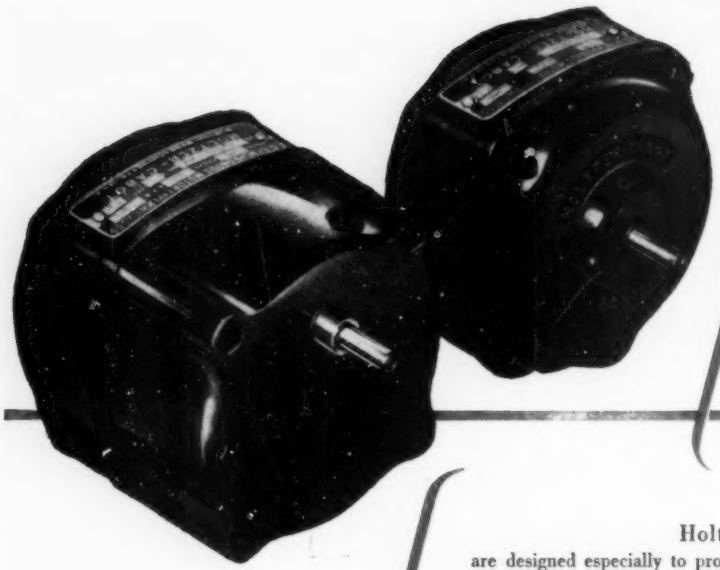
Integral self-alignment of Link-Belt Unmounted Roller Bearings eliminates need for expensive, cumbersome self-aligning housings. Angular contact, concave rollers between convex raceways, provides capacity for thrust and radial loading. Preadjusted for clearance at the factory and packed to reach you in "final inspection" condition, they require no adjustment when you're ready for installation. There's a Link-Belt Bearing Specialist near you who can give you expert advice on *any* bearing application. You can also get all the facts from Data Book 2550.

LINK-BELT

Ball and Roller Bearings

LINK-BELT COMPANY: Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in Principal cities. 12.280

FOR EXTRA FAST STOPS STARTS REVERSES



New TYPE R-24
process control motor

Holtzer-Cabot Type R-24 motors are designed especially to provide the rapid starts, stops and reverses required by modern, high-speed process control equipment. Extremely low rotor inertia, *plus* high accelerating and decelerating torques, provide extremely quick response. Tests show that, with the dynamic braking connection, the unloaded rotor will *always stop within three-quarters of one revolution!* On geared motors, of course, this means that the output shaft stops in a very small fraction of a revolution.

These motors are 2-phase, squirrel-cage, nonsynchronous induction type. For operation on a single-phase circuit, a capacitor is used in series with one phase. Special high impedance windings are available, suitable for matching standard power tubes.

Available speeds, 1300 RPM (1800 synchronous speed) to ¾ RPM (geared), with torque ratings from 0.5 to 75 oz. in. Can be provided for odd voltages and frequencies, with ball or sleeve bearings. These motors are ideal for Servo-Mechanisms.

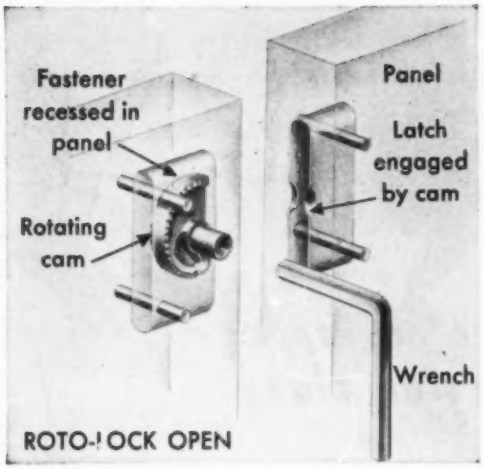
INVESTIGATE NOW. . . Holtzer-Cabot welcomes inquiries involving special motors

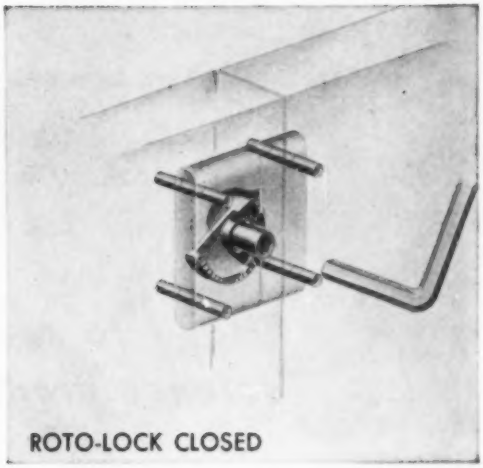
HOLTZER-CABOT

DIVISION OF NATIONAL PNEUMATIC CO., INC.

BOSTON 19, MASSACHUSETTS

"Manufacturers of fine electrical apparatus since 1875"





More than a fastener...

a revolutionary construction principle

ROTO-LOCK makes butt or right-angle joints quickly and securely... simplifies demountable construction

Roto-Lock, the ingenious Simmons locking device, works with just a twist of a wrench... a cam pulls parts together. When gaskets are placed between panels, Roto-Lock exerts sufficient pressure to form a weatherproof, watertight seal.

Easily installed by unskilled labor in *any* material, this revolutionary Simmons Fastener is ideal for any type of demountable construction—from Army shelters or temporary hangars to lightweight knock-down shipping boxes, desks or tables. Recessing completely, Roto-Lock leaves no exposed parts when closed. It will fasten in misaligned conditions.

Built of materials highly resistant to corrosion and wear, Roto-Lock features design simplicity...has no springs or other delicate mechanisms affected by severe climates. Literature, showing numerous Roto-Lock applications and complete design specifications, is available to help you solve *your* fastening problems. Write for it today.

SIMMONS FASTENER CORPORATION
1751 North Broadway, Albany 1, New York

Simmons

SPRING-LOCK • QUICK-LOCK • ROTO-LOCK

STAINLESS STEEL BELLOWS ASSEMBLIES

When time counts—and accuracy and quality are "musts"—you can entrust your stainless steel bellows assemblies needs to us . . . *completely!*

Just turn over the job to us. You're free of production problems and worries. Our skilled personnel—ample facilities—50 years of specialized experience—all combine to produce *exactly* to your specifications. You save *plenty* —time *and* money.

You may need an assembly similar to one we have already produced. Or, you may have a design problem that parallels one we have solved for another customer. Whatever you require, we will work with you to develop assemblies specifically adapted to your requirements.

Sylphon bellows assemblies are used in many ways—where there's a design problem involving control of temperatures or pressures. They open and close valves, dampers, etc., absorb expansion, provide packless construction, have many more uses. Stainless steel or other metals. Wide range of sizes. Send for complete information. Ask for idea-packed Catalog RP-1200.

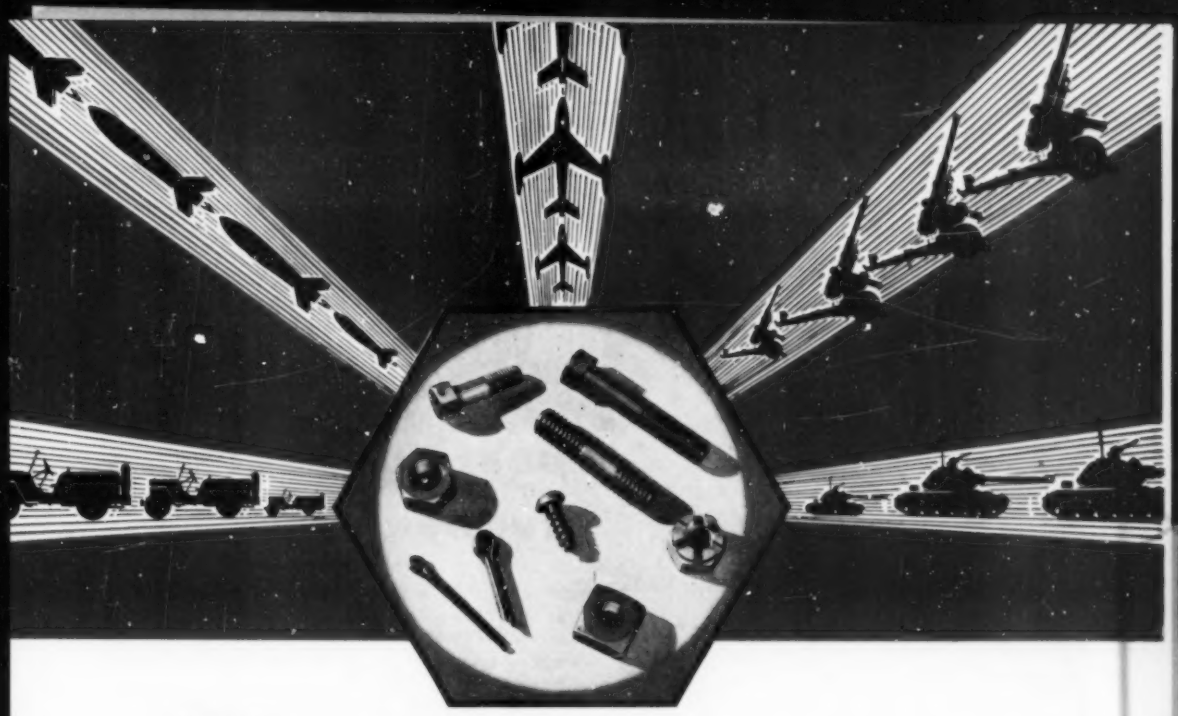
TEMPERATURE CONTROLS

FULTON SYLPHON DIVISION Knoxville 4, Tenn.

Robertshaw-Fulton CONTROLS COMPANY

BELLOWS ASSEMBLIES • BELLOWS DEVICES

BRIDGEPORT THERMOSTAT DIVISION Bridgeport 1, Conn.



Fasteners

. . . for our "First Lines" of Defense!

Granted—our Armed Forces have always been our First Lines of Defense. This is a proud distinction nobody can usurp.

But even before the men of our Army, Navy and Air Forces can go into action, the Production Lines of the country must supply the "tools" for the job.

Lamson & Sessions manufactures fasteners which play a vital part in keeping these "first lines" rolling. For practically every finished product requires bolts, nuts, screws, cotters, etc. In fact, over 2% OF THE STEEL PRODUCED IS USED TO FASTEN THE REST TOGETHER.

You who run the production "first lines of defense" are welcome to consult Lamson anytime on fastener problems.

The home of "quality controlled" fasteners

Lamson + Sessions

L S

The **LAMSON & SESSIONS** *Co.* • General Offices: 1971 West 85th Street • Cleveland 2, Ohio

Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

Here's what we're doing

about the steel wire situation:

FIRST, of course, we're pushing production to the very limit.

Second, we're working with you, the user, to help you get the most out of the wire you're getting. Here's what we mean:

If you're having steel wire trouble, turn your problem over to our metallurgists. They've tangled with just about every problem in the history of wire fabrication. A problem that is totally new to you, may be a simple matter of recorded history for us.

For example: You may be using a wire that's unsuitable for the job it has to do. Perhaps a different grade can be used that will give the desired performance. Maybe your fabricating techniques can be improved, resulting in more uniform physical properties and less scrap.

You may be able to improve your product and actually cut your costs at the same time. We've seen that happen plenty of times.

In any event, if you have a wire problem, we'll be glad to give you all the help we can. We've always offered this service, but we think it's particularly valuable now.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

AMERICAN MANUFACTURERS WIRE

AMERFINE—*High-quality fine wire.*

AMERSPRING—*music steel spring wire.*

AMERLOY—*alloy heading wire.*

AMERTEMP—*heavy-duty oil-tempered wire.*

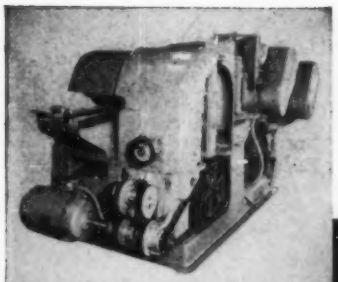
AMERHEAD—*uniform heading wire.*

AMERSTITCH—*extra-tough metal stitching wire*

AMERICAN
MANUFACTURERS WIRE

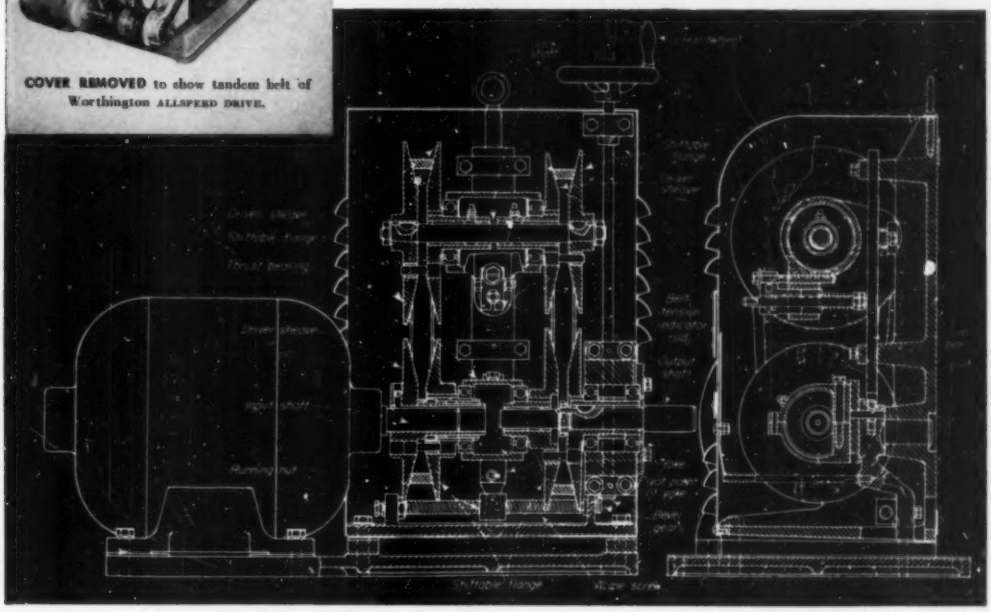
USS

UNITED STATES STEEL



COVER REMOVED to show tandem belt of Worthington ALLSPEED DRIVE.

Two Belts Take Up Less Room Than One!



CROSS-SECTIONAL views of Worthington ALLSPEED MOTOR DRIVE.

New variable speed drive gives wider speed variation in limited space

And belt *replacement* is reduced, too!

Those are two of the reasons why the new Worthington ALLSPEED DRIVE is your best specification for variable speed control.

The "tandem-belt" design gives a greater range of instantaneous, stepless variations than the single belt used in other variable speed drives. And it permits using a *narrower* belt than other drives—this means less wear from flexing and compression, longer life.

Other advantages: Easy belt replacement—don't have to dismantle the unit • Automatic positive belt tensioning • All wearing parts bronze-bushed • All ball bearings shielded and life-lubricated • In-line input and output shafts • Can be run in either direction.

MODELS TO SUIT YOUR DESIGN

Six sizes from 1-15 hp; up to 16-1 range of variation.

Covered or skeleton models—or supplied less any parts, such as without shifting parts for attachment to your shifting mechanism.

With or without built-in motor—standard NEMA Frame 1750 rpm motor.

Upright or horizontal frame.

Extended control yoke available.

Send coupon for Worthington Allspeed Drive bulletins AS-1600-B3 and AS-1600-B4. Worthington Pump and Machinery Corporation, Worthington Allspeed Drive Division, Holyoke, Massachusetts.

WORTHINGTON

AS.1.3

THE GOOD RIGHT HAND OF INDUSTRY

POWER TRANSMISSION: sheaves, V-belts, variable speed drives

PUMPS: centrifugal, power, rotary, steam

AIR COMPRESSORS: water-cooled, air-cooled

Worthington Pump and Machinery Corporation
Worthington Allspeed Drive Division
Holyoke, Massachusetts

Please send bulletins AS-1600-B3 and AS-1600-B4 on Worthington Allspeed Drive.

Name.....

Company.....

Address.....

DIE CASTING
means "happy landings" for a host of production projects

CASE HISTORIES FROM MT. VERNON FILES

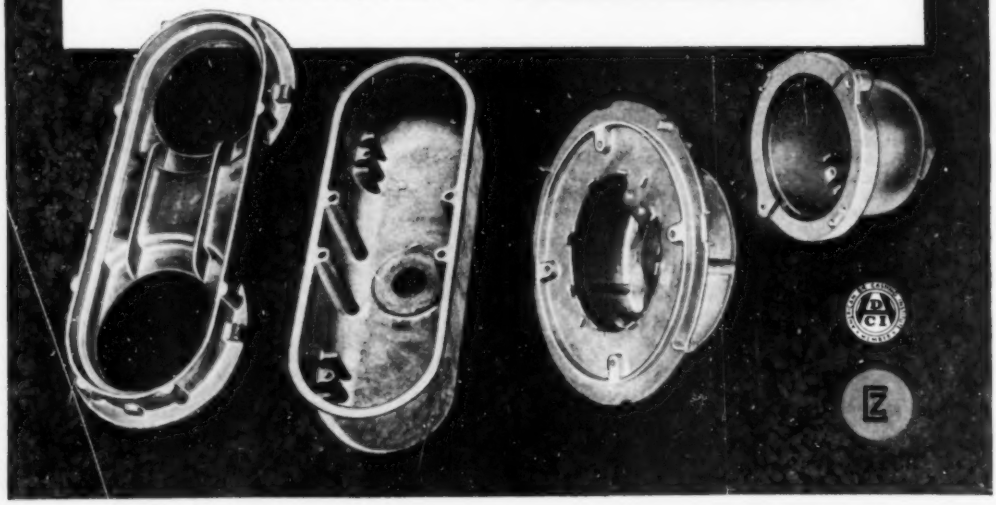
Start to plan a production job, and immediately you must figure out how to "land" on the credit side of the ledger. Get the work rolling, and you must keep within the boundaries of estimated costs at each stage of production.

These are good reasons for considering die casting every time you have to specify a manufacturing procedure. For die casting is a quick, cost-cutting means of producing items for thousands of applications . . . superior products that can be sold competitively.

Says American Gas Accumulator Company, of Elizabeth, New Jersey. "The various die-cast parts made for us by Mount Vernon, for use in our airport runway and obstruction lights, not only help us hold down manufacturing and assembly costs, but contribute importantly to the quality of our products and their successful operation under rugged outdoor conditions."

That's die casting!—fast, economical production; "clean" parts which require little or no machining, and adapt themselves readily to all types of finishing; dependable end products.

Numerous manufacturers have found die casting a "top flight" method for saving time and materials, stepping up output and reducing unit costs. Why not send us your specifications. We feel confident we can show you how to profit likewise.



These highly experienced, thoroughly responsible distributors (one near you) stock and recommend

BOST-BRONZ®

OIL IMPREGNATED

BEARINGS

With Oil Film Always Present All Over

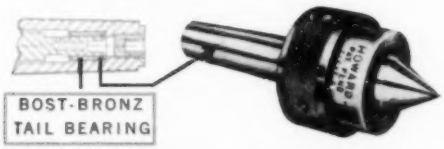
For heavy loads — light loads

high speeds — low speeds

static loads — shock loads

AKRON, OHIO
ALBANY, NEW YORK
ALLENTOWN, PENNSYLVANIA
ATLANTA, GEORGIA
BALTIMORE, MARYLAND
BIRMINGHAM, ALABAMA
BOSTON, MASSACHUSETTS
BRIDGEPORT, CONNECTICUT
BROOKLYN, NEW YORK
BUFFALO, NEW YORK
CHARLOTTE, NORTH CAROLINA
CHATTANOOGA, TENNESSEE
CHICAGO, ILLINOIS
CINCINNATI, OHIO
CLEVELAND, OHIO
COLUMBUS, OHIO
DALLAS, TEXAS
DAYTON, OHIO
DENVER, COLORADO
DES MOINES, IOWA
DETROIT, MICHIGAN
GRAND RAPIDS, MICHIGAN
GREENSBORO, NORTH CAROLINA
HAMILTON, ONTARIO
HARTFORD, CONNECTICUT
HOUSTON, TEXAS
INDIANAPOLIS, INDIANA
JACKSONVILLE, FLORIDA
KANSAS CITY, MISSOURI
KNOXVILLE, TENNESSEE
LANCASTER, PENNSYLVANIA
LONDON, ONTARIO
LONG ISLAND CITY, NEW YORK
LOS ANGELES, CALIFORNIA
LOUISVILLE, KENTUCKY
MEMPHIS, TENNESSEE
MIAMI, FLORIDA
MILWAUKEE, WISCONSIN
MINNEAPOLIS, MINNESOTA
MONTREAL, QUEBEC
NASHVILLE, TENNESSEE
NEWARK, NEW JERSEY
NEW ORLEANS, LOUISIANA
NEW YORK, NEW YORK
OAKLAND, CALIFORNIA
PHILADELPHIA, PENNSYLVANIA
PITTSBURGH, PENNSYLVANIA
PORTLAND, OREGON
PROVIDENCE, RHODE ISLAND
QUEBEC, QUEBEC
QUINCY, MASSACHUSETTS
RICHMOND, VIRGINIA
ROCHESTER, NEW YORK
ST. LOUIS, MISSOURI
SAN JOSE, CALIFORNIA
SAN FRANCISCO, CALIFORNIA
SEATTLE, WASHINGTON
SPRINGFIELD, MASSACHUSETTS
SYRACUSE, NEW YORK
TAMPA, FLORIDA
TOLEDO, OHIO
TORONTO, ONTARIO
TRENTON, NEW JERSEY
VANCOUVER, B. C.
WATERBURY, CONNECTICUT
WILKES-BARRE, PENNSYLVANIA
WINSTON-SALEM, NORTH CAROLINA
WORCESTER, MASSACHUSETTS

take heavy loads, for example:



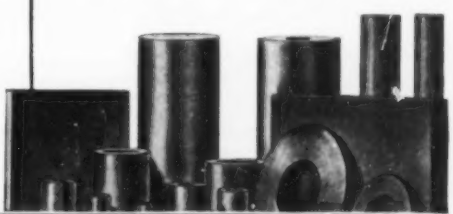
this *live-center* made by Melin Tool Co., Inc. of Cleveland, has been turning thirty ton turbine shafts for 15 months. The tail bearing is BOST-BRONZ. It's still as good as new! Frictionless and solid bronze bearings were tried but none would stand up under the terrific loads involved. BOST-BRONZ standardized, stock bearings proved the answer to years of searching for the right bearing.

STOCKED in a wide range of sizes in 6 types — cylindrical bearings, flange bearings, thrust bearings, cored bars, solid bars and plate stock.

FIVE GREAT ADVANTAGES

BOST-BRONZ Bearings are

1. *better* — interchangeable with solid bronze but superior in performance.
2. *quieter* — an oil film to start on as well as run on.
3. *cleaner* — no oil drip or waste. No openings for grit, lint or dirt.
4. *easier to use* — no machining — simple press fits.
5. *more economical* — no oil holes or grooves to machine — longer service.

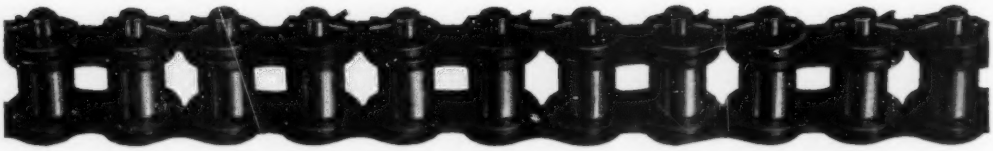


GET THIS CATALOG

Write for Catalog 53. It contains a wealth of useful data and selection charts.

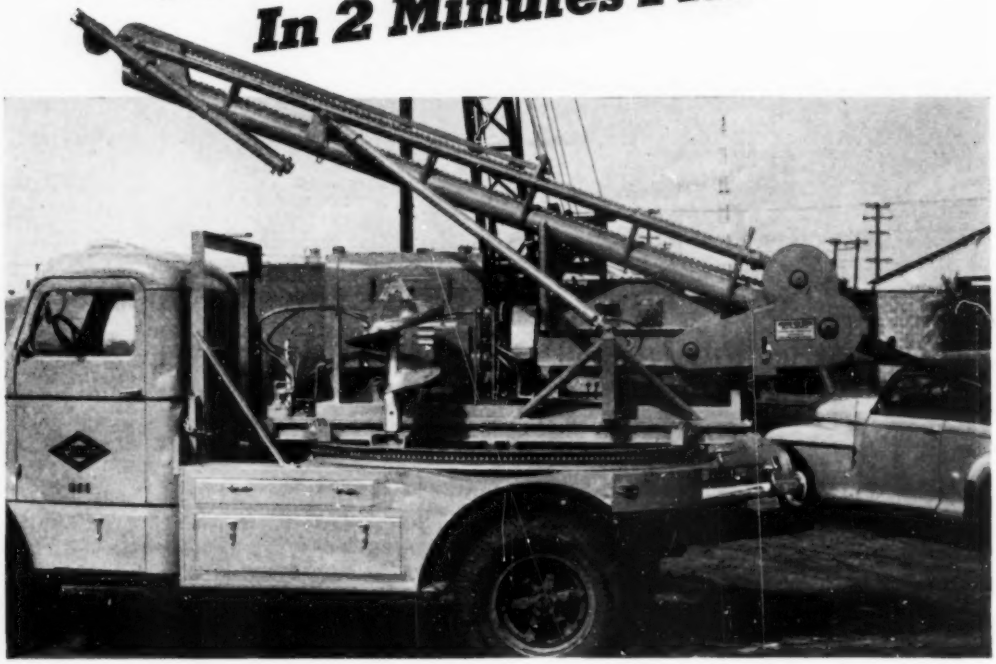
BOSTON GEAR WORKS

71 HAYWARD ST., QUINCY 71, MASS.



WHITNEY CHAIN DRIVES

Help the Williams Hole Digger Put Down a 9 Foot, 18 Inch Diameter Hole In 2 Minutes Flat



This ingenious machine, manufactured by the Hugh B. Williams Manufacturing Company, can dig holes up to 3 feet in diameter and 9 to 25 feet deep by variations in the unit. Under normal conditions the digger can put down a 9 foot, 18 inch diameter hole in two minutes. That's speed... and it calls for a ruggedly built chain drive that will travel and stand up too.

For positive power transmission and high performance under all operating conditions, Williams uses Whitney Chains throughout for driving the various units. Despite rocks and other obstructions often encountered, Whitney Roller Chains take tough usage in stride — keep working, day in, day out.

Here's what this company says about Whitney Chain performance:

"We have been consistently using Whitney Chain in our machines because we have always found it to be strong, uniform and of excellent construction throughout. Wearing qualities are above average and in our machines, which are used in all weather conditions, this is very important. In short, we feel that your chain has given excellent performance in every respect". — T. E. Green, Sec. Treas.

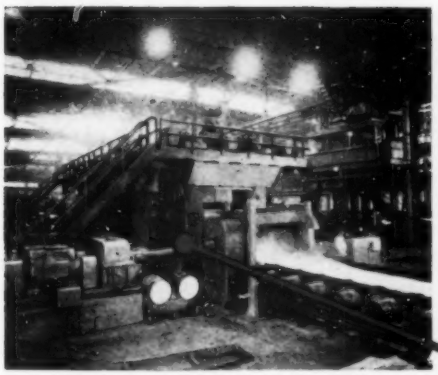
You, too, can keep your equipment operating longer, simplify your designs and cut costs by standardizing on Whitney Chain Drives.

Consult your local Whitney Field Office or Distributor, or write direct for complete information and catalog.

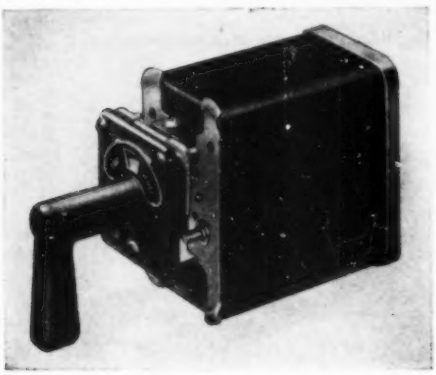
WHITNEY CHAIN COMPANY

204 Hamilton Street, Hartford 2, Connecticut

Versatile switch simplifies control of huge hot strip mill



86 in. Hot Strip Mill, Kaiser Steel Corporation



Another job made easy by G-E

SB CONTROL AND TRANSFER SWITCHES

RED HOT STEEL STRIP races at nearly 1500 feet per minute from the big mill of the Kaiser Steel Corporation at Fontana, California. Precision control of speed, tension, width, thickness and the flying shear which cuts the steel "on the run" requires many circuit-sequence combinations. Sturdy General Electric SB switches provide the necessary versatility and assure reliable performance.

THIS IS JUST ONE EXAMPLE of the thousands of control installations made easy with the compact, versatile family of SB-type switches. By varying the cam and finger arrangements and number of stages, design engineers have utilized the General Electric SB-1-type switch, for example, with over 10,000 circuit-sequence control combinations. Standard parts and simple basic design mean long life and dependable operation.

FOR FURTHER DETAILS see your G-E sales representative, or write for Bulletin GEA-4746, Section 856-76, General Electric Company, Schenectady 5, N. Y.

856-76

GENERAL ELECTRIC

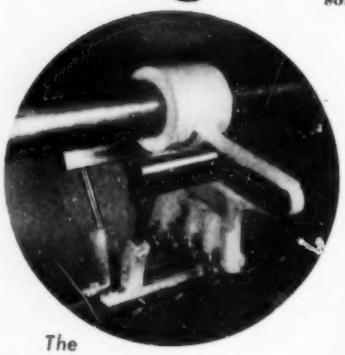
HEIM *Unibal*

SPHERICAL BEARING

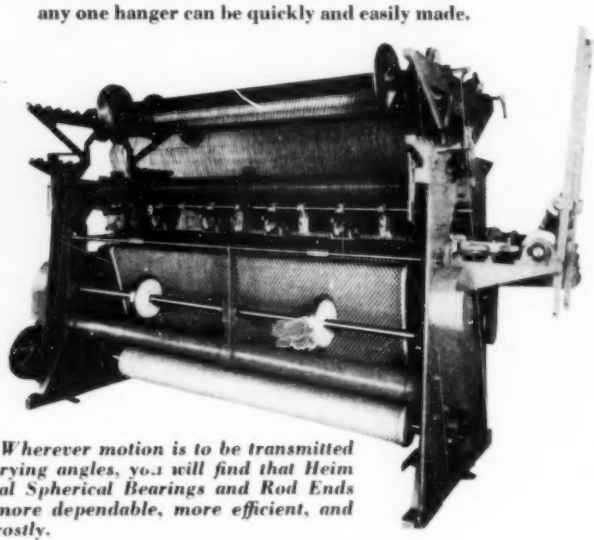
ROD ENDS

as used on the "Kidde Knitter"

The Kidde Knitter, made by Kidde Manufacturing Co., Bloomfield, N. J., newest in Raschel Type Warp Knitting Machines, is used to produce lace edgings, elastic fabric, veilings, polo shirts, and many other interesting fabrics. It can be operated with as many as six Guide Bars. It is essential that these bars move laterally, both smoothly and freely. To accomplish this, Heim Spherical Bearing Rod Ends, used as suspension hangers for each bar, provide an ideal solution, as alignment is simplified and vertical adjustments on any one hanger can be quickly and easily made.



The above section demonstrates how alignment is simplified through the use of Heim Spherical Bearing Rod Ends . . . giving top performance at lower cost.



Wherever motion is to be transmitted at varying angles, you will find that Heim Unibal Spherical Bearings and Rod Ends are more dependable, more efficient, and less costly.

Bearings and Rod Ends catalog sent on request . . .

Write **THE HEIM COMPANY**

FAIRFIELD, CONNECTICUT

The excellent properties of Styron plus good engineering design enable the Federal Tool Corporation, Chicago, to mold these unique closure caps for peanut butter jars. The covers become practical coasters after serving in their original use.

IN JAR COVERS made of STYRON

dimensional stability

built-in colors

lightweight, strong

non-toxic

design freedom

Again the special properties and design freedom of Styron (Dow polystyrene) enable an industry to turn out a better product at reduced production costs. In this case the jar cover for a food product was fabricated from Styron, especially ideal because of its broad chemical resistance. The cover was engineered with an interrupted thread so that it could be removed from the mold with a fraction of a turn, thus providing a release from the under cut. Of particular importance in this application of Styron was its excellent property of maintaining dimensional stability. This meant a very low percentage of rejects and a consequent reduction in production costs.

Dow, a leader in the plastics industry, offers a complete line of *quality-controlled* polystyrene plastics under the trade-mark name Styron. Often the use of Styron eliminates assembly steps, affords greater design freedom, cuts production time and lowers costs. Styron helps improve product appearance for it comes in a wide range of colors. These colors, which keep finishing operations to a minimum, will not chip or peel from the finished article. Dow's Plastics Technical Service is fully equipped to help you determine the applicability of Styron to *your* manufacturing operation. Write Dow today.

Plastics Division—Dept. PL-79

THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington
Atlanta • Cleveland • Detroit • Chicago • St. Louis
Houston • Los Angeles • San Francisco • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

MADE OF STYRON A DOW PLASTIC

The Styron label is the hallmark of quality in plastics goods

DOW plastics

STYRON brand plastics
...basic raw materials serving basic industries.

Investigate

THE ADVANTAGES OF DOING YOUR OWN SLITTING

Send for this book—a practical discussion of important questions as to operation, production and cost.

It contains time studies of output per cycle and per day, in slitting different widths, gauges and coil weights.

It shows how cycle time is affected by these and other factors; advantages of big coils and high speeds for big tonnages; economies of smaller, less expensive, standardized sizes of slitters for the more moderate requirements of most metal working plants.

Cost analyses show how Yoder slitters, operating only three or four days per month, often pay for themselves in a year or two. In addition, they greatly reduce inventory requirements of slit strands and facilitate production planning.

Phone or write today for free copy. Estimates and recommendations for the asking.

THE YODER COMPANY • 5522 Walworth Avenue, Cleveland 2, Ohio

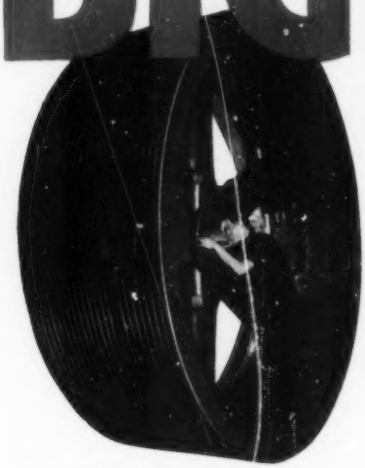
Complete Production Lines

- ★ COLD-ROLL-FORMING and auxiliary machinery
- ★ GANG SLITTING LINES for Coils and Sheets
- ★ PIPE and TUBE MILLS—cold forming and welding

ENGINEERING YODER MANUFACTURING

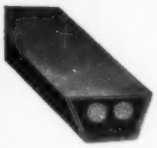
BIG or Small

...EVERYTHING IN V-BELT DRIVES!

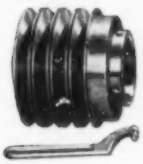


NON-STOCK SHEAVES — These sheaves are made to order from stock patterns for A, B, C, D, or E belts, 1 to 1000 hp. For further information check with your *Texrope* drive dealer or Allis-Chalmers Sales Office.

TEXROPE
Greatest Name in V-Belt Drives



SUPER-7 V-BELT — Famous grommet construction. No splices where failure can start. Rubber cushion supports rayon cord at pitch line. Sizes and sections to suit all operating conditions. All Standard sizes from stock.



VARI-PITCH STANDARD SHEAVE — Speed range of 9% to 28% on drives of 1 to 300 horsepower, using A, B, C, D, or E belts. Two to 10 grooves. These sheaves are available in either motion control or stationary control.

AUTOMATIC VARI-PITCH SHEAVES — Offer stepless speed control . . . one to 40 hp . . . 2 to 1 speed range. Move motor forward to increase speed, and back to decrease. One hand does it while motor is running.

MAGIC-GRIP SHEAVES— Fastest mounting sheave you can buy. Aligns easily . . . cannot shake loose. 1 to 12 grooves for A-B, B, C, and D belts. 1 to 250 hp. Stocked in many cities for immediate delivery.

TEXSTEEL SHEAVES — Pressed steel sheaves for applications from ¼ to 25 horsepower. Light weight and rigid. 1 to 6 grooves, A or B belts. All sizes and bores are available for delivery from stock.

VARI-PITCH SPEED CHANGER—Smooth, accurate speed control at turn of hand wheel. Machines operate at exactly the speed for best production. Stepless speed range: 3¾ to 1. Capacity: 1½ to 75 hp.

YOU CAN GET every V-belt drive component from the *Texrope* line: Constant speed drives; standard and wide range *Vari-Pitch* drives; speed changers; motor bases; and new or replacement long lasting *Super-7* V-belts.

Get Added Benefits

In addition, you get extra engineering skill both in the field and factory that comes from having more industrial V-belt installations than any other manufacturer.

The world's greatest store of V-belt engineering knowledge has been condensed into a 120 page *Texrope* Pre-Engineered Drive Book. Covers 90% of all V-belt drive requirements. Ask your Allis-Chalmers Authorized Dealer or Sales Office for Bulletin 6956A, or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-3272

Texrope, Super-7, Vari-Pitch, Texsteel, and Magic-Grip are Allis-Chalmers trademarks.

ALLIS-CHALMERS

Sold . . .
Applied . . .
Serviced . . .

by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

MOTORS — ½ to 25,000 hp and up. All types.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

PUMPS — Integral motor and coupled types from ¾ in. to 72 in. discharge and up.

Mallory Jacks and Plugs

for exacting specifications

Shown above are three military type Mallory jacks . . . part of the group of five types available for civilian and mobilization uses.

1. Long Frame Jacks—Threaded bushing. Mounting takes up depth, but little panel space. The spring stack-ups are mounted horizontally to the frame in a variety of spring combinations.

2. XP Long Frame Jacks—Plain, unthreaded bushing. Mounting is accomplished by a screw-nut combination. Takes up depth, but little panel space. These jacks serve the same purpose as the Mallory Standard Long Frame Jacks, but a special frame angle is employed to give greater support.

3. Junior Jacks—Threaded bushing. Mounting is parallel to panel, thus requiring less depth, but more panel space. Built with the frame supporting the spring stack at a right angle so that the jack extends only $1\frac{5}{16}$" back of the panel.

4. SC Jacks (Signal Corps Type)—Threaded bushing. Condensed size with medium panel area, minimum depth. Designed for use in all applications, but especially where limited space is important. Built to comply with JAN specifications.

5. "Grounding" Jacks No. GJ-1—Threaded bushing. Used in military aircraft to "ground" planes while refueling.

The precision and dependability of the Mallory line of jacks and plugs are the result of a unique combination of research facilities and production skill.

Specialized experience in the related fields of metallurgy, electrical contacts and electronics qualified Mallory to work in close cooperation with the Armed Services Electro Standards Agency since its inception. Mallory jacks and plugs meet a wide variety of application requirements and include a number of military types complying with JAN specifications.

Mallory jacks and plugs are available for your most exacting needs. Qualified engineering service and technical data are available on request.

Television Tuners, Special Switches, Controls and Resistors

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

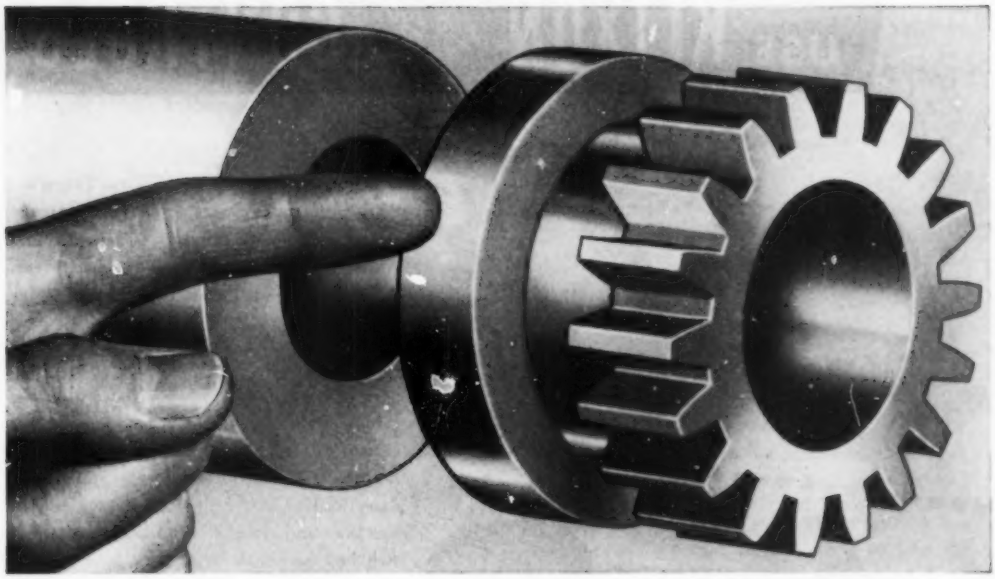
SERVING INDUSTRY WITH

Electromechanical Products
Resistors *Switches*
TV Tuners *Vibrators*

Electrochemical Products
Capacitors *Rectifiers*
Mercury Dry Batteries

Metallurgical Products
Contacts *Special Metals*
Welding Materials

How to get more parts out of a ton of steel!



WHEN you use Timken® seamless tubing for your hollow cylindrical parts, the hole is already there. As a result, you machine away less scrap than you do with bar stock—get more parts per ton of steel.

Using tubing also boosts the productivity of your machine tools. Since drilling the center hole is eliminated, finish boring is often your first production step. Screw machine stations are released for other operations. You have more machine capacity without adding more machines.

What about quality of product? Because the piercing process by which Timken tubing is made is basically a forging operation, the tubing has a uniform spiral grain flow for greater strength and a refined grain structure which brings out the best in the quality of the metal. And this fine forged quality is uniform from tube to tube and heat to heat, thanks to the Timken Company's rigid quality control.

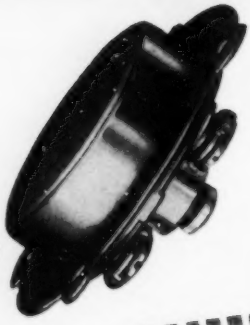
As further help in saving steel, the Timken Company offers a tube engineering service which recommends the most economical tube size for your job. And the recommended tubing is *guaranteed* to clean up to your finish dimensions. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

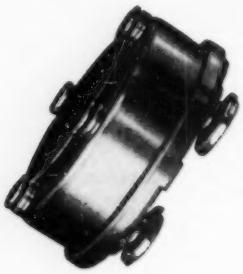
YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

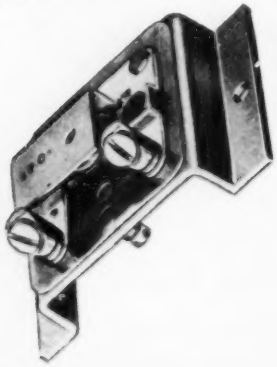
Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing

For Accurate Temperature Control in Military and Civilian Products . . .

USE KLIXON *Thermo Snap* CONTROLS







The positive snap action of Klixon Thermo-Snap Controls provides a *quick, clean break* or a *fast, solid make* assuring dependable, accurate temperature control wherever used . . . and usually at a cost lower than general purpose controls.

Today, Klixon *Thermo-Snap* Controls are used in many military and civilian products ranging from tanks, airplanes, radio and electronic equipment, sterilizers and unit heaters to household electrical appliances, dairy heaters, etc. Applications include — low limit and high limit controls, fuel delay switches, purges switches, temperature controls, fan switches, tube and rectifier cooling control, etc.

Klixon *Thermo-Snap* Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges. Our engineers will gladly help you with your problems. Write for information.

KLIXON

SPENCER THERMOSTAT
Division of Metals & Controls Corp.
909 FOREST ST., ATTLEBORO, MASS.

KLIXON MOTOR PROTECTORS PREVENT MOTOR BURNOUTS

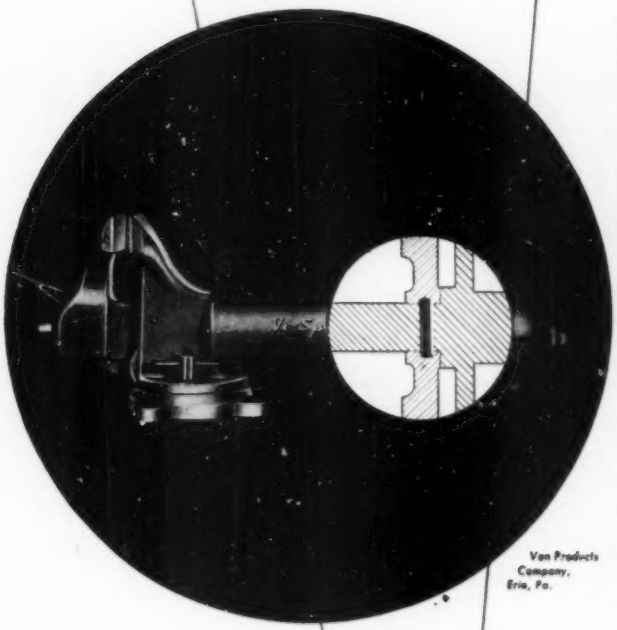
To keep motors operating longer specify and use motors with built-in Klixon Protectors. Should a motor become overheated, the Klixon Protector snaps the power "off," preventing a motor burnout. When it cools to safety, the protector snaps the power "on" automatically if the automatic reset is specified. The manual reset type permits the power to be snapped "on" again only when the red button is pushed.

OIL RESISTANCE

LOW COMPRESSION SET

These properties of neoprene make a better

PNEUMATIC VISE



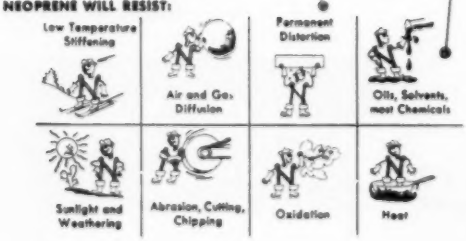
Van Products Company, Erie, Pa.

Speed of operation, simple adjustment, and a tremendously powerful grip are the results of re-designing this pneumatic vise. Small as it is, the molded neoprene packing ring plays a big part in the tool's improved efficiency. The packing ring replaces eight parts, eliminates three machine operations and, by reducing friction, increases the power and speed of the tool.

Neoprene's low compression set means that even after repeated application of pressure this packing ring will retain its resilience and shape. What is more, neoprene's excellent resistance to deterioration from oil and grease means it will retain its resilient properties. In short, neoprene's unique properties make this vise practical.

Designers looking for a resilient material to do a critical job will find neoprene the answer to many of their problems. Rubber goods manufacturers can compound neoprene to meet a variety of exacting requirements.

PROPERLY COMPOUNDED NEOPRENE WILL RESIST:



DU PONT

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

NEOPRENE

The rubber made by Du Pont since 1932

FREE! **THE NEOPRENE NOTEBOOK**

Full of interesting stories. New, unusual applications of neoprene to build new products . . . improve old products . . . reduce maintenance costs.

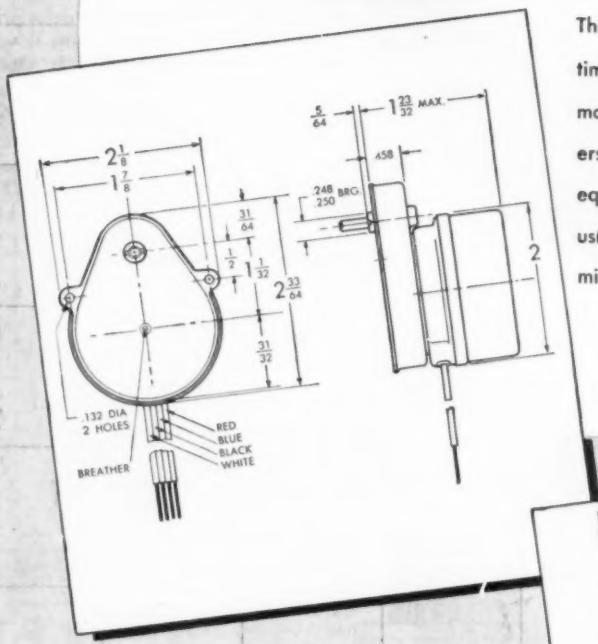
E. I. du Pont de Nemours & Co. (Inc.)
Rubber Chemicals Div. B-9, Wilmington 98, Del.
Please send me free issues of **The Neoprene Notebook.**

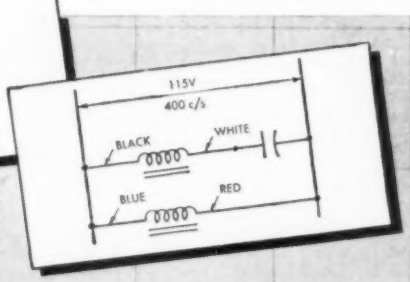
*Name*_____
*Position*_____
*Firm*_____
*Address*_____

Another HAYDON

400 CYCLE

HAYDON research and engineering staffs constantly seek to develop new and build better products. One example is the HAYDON 400 cycle timing motor. This is an hysteresis type synchronous timing motor, for use as a separate motor or in many different types of timers. HAYDON personnel and plant are equipped to build motors and timers using D.C., 60 cycle or 400 cycle for military or civilian applications.





FIRST *in Timing*

SYNCHRONOUS TIMING MOTORS and TIMERS

SPECIFICATIONS:

Hysteresis type synchronous timing motor, essentially two phase . . . furnished with capacitor for self-starting operation on single phase . . . standard gear trains available, special designs available for quantity production . . . speeds available with standard gear trains range from 1/60 to 30 rpm . . . weighs approximately 6-1/2 oz. . . . dimensions, except for slightly greater depth, closely follow those of HAYDON 60 cycle timing motors.

FEATURES:

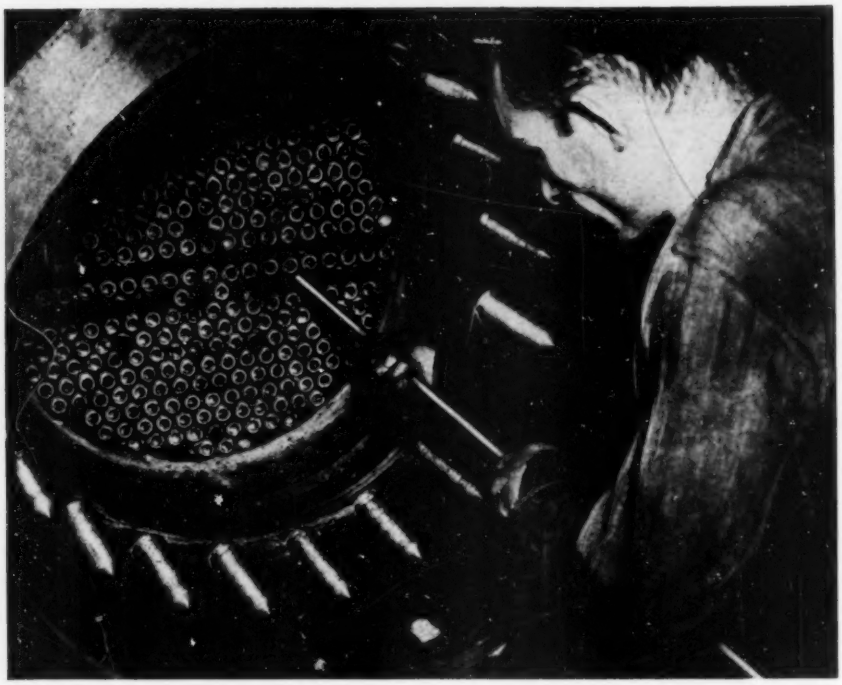
Inherently accurate approach to timing problems. Not affected by variations in temperature, supply voltage, load and altitude. R-F filtering or shielding not required. Brush life or wear not a problem. Where primary current supply is 400 cycle, rectifying equipment and duplication of wiring may be reduced or eliminated.

Write for a copy of Engineering Bulletin #2 for complete information on the 400 cycle motor.

HAYDON
AT TORRINGTON

HEADQUARTERS FOR
TIMING

HAYDON Manufacturing Co., Inc.
SUBSIDIARY OF GENERAL TIME CORPORATION
3133 ELM STREET
TORRINGTON CONNECTICUT



One of the "Four Hundred"

EVERYTHING'S going up. Everything, that is, except the cost of *power*. Fuel is up. Labor is up. Equipment cost is up. But not the cost per delivered kilowatt-hour.

Power plant engineers let you in on the secret: "It's a principle," they say, "*the higher you raise steam temperature and pressure, the more power you get per pound of fuel.*"

But there's an added factor in this seemingly simple formula. For already, boiler pressure-temperatures have been pushed up until the steam lines glow red; and that calls for supplying feedwater under conditions that are something special. Look, for example, at the heater pictured here.

It contains more than 400 metal tubes, totalling 5 miles in length. Every minute, the heater rams 1000 gallons of 450°F. water into the thirsty maw of the main boiler at a pressure of 3,200 pounds per square inch.

So there, Mr. Designer, is your problem. To find a material to make those thin-wall tubes with the strength to stand such temperatures and pressures . . . plus a few extras for good measure:

Tubes must be elastic, to shrink and swell in tune to the steel tube sheets; possessed of high heat transfer properties, an extremely low corrosion rate, erosion-resistant, and easy to weld.

The designers who faced those eight "musts" found their answer in one metal: Monel, one of the family of INCO Nickel Alloys.

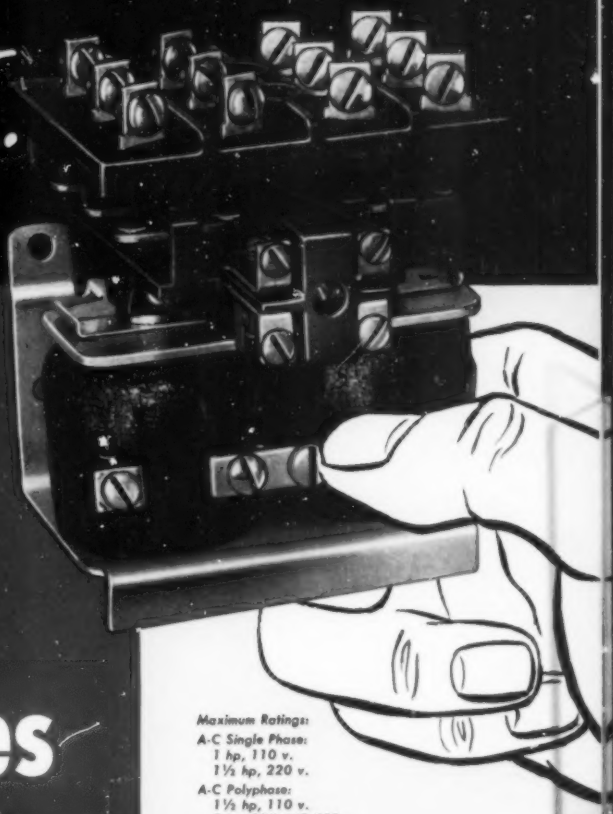
What of the Metal Problem facing You?

Could one or another of the Inco Nickel Alloys help you solve it? Very possibly. Write us about it. Under present conditions, so much Nickel is needed for defense work that we have to stretch our production to cover the most essential needs for INCO NICKEL ALLOYS. But we are ready right now to help you with ideas and suggestions for your present production and future planning.

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.

Nickel INCO **Alloys**

New...



BULLETIN 705

STYLE A—A-C OR D-C

Reversing Switches

Here is a new, low cost, automatic reversing switch . . . extremely small in size . . . for small hoists, light monorail cranes, overhead doors, and other similar services.

Bulletin 705 Size A Reversing Switch in Type 1 Enclosure.

Bulletin 705 reversing switches consist of two mechanically interlocked solenoid contactors. Style A is for 2 wire control; Style B has auxiliary contacts for 3 wire control.

These small reversing switches have the same trouble free solenoid action and maintenance free contacts on which the reputation of other Allen-Bradley controls has been established.

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.

Maximum Ratings:

A-C Single Phase:
1 hp, 110 v.
1½ hp, 220 v.

A-C Polyphase:
1½ hp, 110 v.
2 hp, 220-440-550 v.

D-C: ¾ hp, 115-230 v.

- SMALL SIZE
- LOW COST
- SIMPLE SOLENOID MECHANISM
- DOUBLE BREAK SILVER ALLOY CONTACTS
- MECHANICAL INTERLOCK
- AUXILIARY CONTACTS FOR 3 WIRE CONTROL

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

A-B Quality

6-51-R

Announcing . . .

A-B Quality

Bulletin 350
STYLE A

Compact

Low Cost

Reversing Drum Switch

For a-c and d-c motors rated 2 hp or less

The new Bulletin 350 manually operated reversing drum switch provides a reliable unit for applications where space is at a premium and low cost is an all important factor. It is equivalent to a three pole, double throw switch equipped with quick make action. Contacts are cadmium silver alloy, eliminating the need for maintenance.

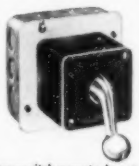
Bulletin 350 reversing switches are ideal for small workshop tools and for medium duty industrial service. They can be used with d-c motors, or single phase, two phase, or three phase a-c motors, rated two horsepower or less. Send for Bulletin 350.

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

MOUNTING ARRANGEMENTS

With mounting angle and double conduit opening.



Drum switch mounted on standard square junction box.

With cover plate for cavity mounting in machine base.

Switch mounted on standard octagonal junction box.

6-51-R

NATIONAL OIL SEAL LOGBOOK

Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California office

Where Pressure Lubricating Systems are Employed— Dependable Oil Seal Performance is a Must

Many machinery manufacturers are adopting pressure lubricating systems in their new designs. This method of lubrication insures longer trouble-free performance, reduces maintenance costs and eliminates shut-down time ordinarily required for periodic manual greasing.

The new Emsco "GB-800" oil field drilling rig is a fine example of heavy equipment which employs pressure lubrication. In this new unit more than 25 oil seals are employed on shafts ranging in size from $1\frac{1}{2}$ to 10 inches. As shown in the photo of the drawworks (Fig. 1), three engines, transmission and hoist are mounted on a common skid and can be transported as a unit. The cut-away drawing (Fig. 2) is of the main hoist drum shaft assembly. The pressure lubricating system is piped to bearings on the main shaft and in the idler sprocket. Oil flows through the bearing assembly flushing out all dirt or other foreign matter.

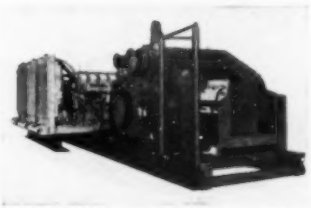


Fig. 1—New Emsco "GB-800" skid-mounted rig for portable derrick operation

National leather sealing members are specially treated to retain their shape and maintain an effective seal when subjected to such extraordinary operating conditions. These same type National leather seals have established performance records in many heavy duty applications on shafts up to three feet in diameter.

If you are working on a design for heavy duty equipment, remember: National Oil Seals are, daily, establishing performance records. The seals you need are probably listed among National standard designs already in production for you. Investigate and see for yourself. No cost or obligation, of course.

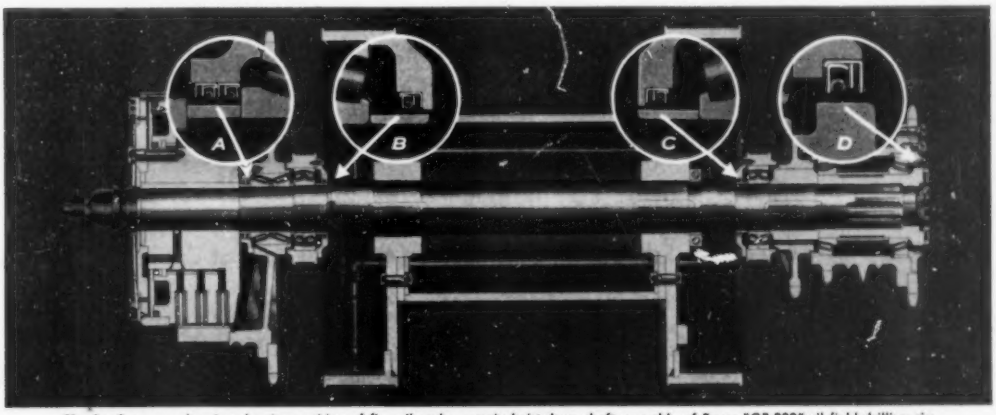


Fig. 2—Cut-away drawing showing position of five oil seals on main hoist drum shaft assembly of Emsco "GB-800" oil field drilling rig

In this drum shaft section, five single-lip, spring-loaded National 50,000 series seals (Fig. 3) are employed. Near the clutch position (A) two of these seals are mounted in tandem to provide protection against leakage into the clutch. The lubricating system places the relatively large oil seals under a constant internal pressure. The equipment is also subjected to frequent reversing and heavy load shocks resulting in a strenuous heavy duty sealing problem.

Fig. 3—National 50,000 series leather oil seal

"Let Your Decision be Based on Precision"

NATIONAL OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City, Calif.; Downey (Los Angeles County), Calif.; Van Wert Ohio

2279

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

BUFFALO, N. Y. . . . . *Room 1124, Prudential Bldg., Mohawk 9222*
CHICAGO, ILL. . . . . *Room 2014 Field Building, Central 6-8663*
CLEVELAND, OHIO . *210 Heights Rockefeller Bldg., Yellowstone 2-2720*
DALLAS, TEXAS . . . *30½ Highland Park Village, Justin 8-8453*
DETROIT, MICH. . . . . *726 Lothrop Avenue, Trinity 1-6363*
DOWNEY (Los Angeles Co.), CALIF. . *11634 Patten Rd., Topaz 2-8166*
WICHITA, KANSAS . . . . *519 South Broadway, Wichita 2-6971*
MILWAUKEE, WIS. . . . *647 West Virginia Street, Broadway 1-3234*
NEW YORK CITY, N. Y. . . *122 East 42nd Street, Lexington 2-8260*
PHILADELPHIA, PA. . . . *401 North Broad Street, Bell-Walnut 2-6997*
REDWOOD CITY, CALIF. . . *Broadway and National, Emerson 6-3861*
WEST SPRINGFIELD, MASS. . . *1025 Elm Street, Springfield 2-1881*
SYRACUSE, N. Y. . . . . *P.O. Box 1224, Baldwinsville 662*

You Can Help S-T-R-E-T-C-H

the supply of stainless pipe by specifying Schedule 5

Sure, Stainless Pipe is tough to get these days. But by specifying LIGHT WEIGHT *Schedule 5* you can help the mills almost double the supply

Here is the answer

Wherever you buy your Stainless Pipe, get all the facts about the strength and other technical advantages of LIGHT WALL *Schedule 5* pipe. It weighs half as much as Schedule 40 pipe. It costs half as much. And it uses half the nickel and chrome because of its LIGHT WALLS. Yet, with all that, *Schedule 5* Stainless Pipe is plenty strong enough to give you complete safety for working pressures up to 150 psi. In sizes under 1½", working pressures can be considerably higher.

Before planning your next job "the same old way" with Schedule 40 pipe, talk to your steel distributor or producer. Consider taking full advantage of the strength of Stainless, by using LIGHT WEIGHT *Schedule 5* Stainless Pipe.

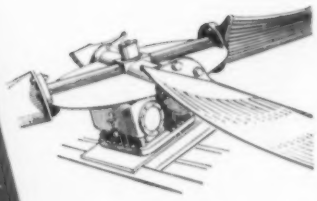
And here's your chance—Call your Carpenter Stainless Tubing Distributor or write to us for this set of Data Sheets on *Schedule 5* Stainless Pipe. They show *why* and *how Schedule 5* offers all industry more Stainless Pipe for essential uses.

THE CARPENTER STEEL COMPANY
Alloy Tube Division, Union, N. J.
Export Department: Carpenter Steel Co., Reading, Pa.—"CARSTEELCO"

Carpenter

STAINLESS TUBING & PIPE

- guaranteed on every shipment



Cleveland Cooling Tower Drives (built in sizes 50 CU to 500 CU inclusive) are rated under Class 2 service conditions, except that thermal limitation does not apply. Heavy, externally ribbed housing effectively dissipates heat to air stream.

Cleveland Type CU...ideal drive for cooling towers

● This worm gear drive is designed specifically for cooling tower service. It meets a long-felt need for a compact, heavy duty speed reducer that will operate continuously, at high speeds and for long periods. It is inherently quiet in operation. Extreme conditions of heat and humidity do not affect it. It carries high thrust loads and high radial loads without loss of efficiency. It lends itself to rugged mounting, and due to the simplicity of its design, it is easily installed, serviced and adjusted in the field.

Every CU drive is run in and pretested under load before it leaves the factory. Thousands of units now in use prove its reliability in all classes of service—in the oil fields, in industry, in air conditioning systems in commercial and public buildings—in short, wherever there's a cooling tower, you can depend on CU.

Write for Bulletin 135 for full description of Type CU. Ask also for free literature on other Cleveland units. The Cleveland Worm & Gear Co., 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers

You're always right with AUTO-LITE

Industrial Wire & Cable

• The quality of Auto-Lite Wire and Cable is the result of nearly 40 years of experience, research and advanced laboratory tests. This, plus the tremendous output possible in Auto-Lite plants at Port Huron, Michigan and Hazelton, Pa., makes Auto-Lite a logical source of supply for wire to fit every need. Address inquiries to:

The Electric Auto-Lite Company
Wire and Cable Division
Port Huron, Mich. Hazelton, Pa.

MAGNET WIRE
Round Single and Heavy Formvar
Round Enameled and Formvar Single Cotton, Round Double Cotton
Round, Rectangular and Square Double Paper Single Cotton
Round, Rectangular and Square Vega Chromoxide
Tinned Copper Wire
AUTOMOTIVE
Ignition Cable Neoprene Sheathed
Low Tension Cable Color Combinations
Battery, Starter and Ground Cable
AIRCRAFT
Plastic Insulation—Special "B" Cotton Braid—"CA" Lacquer
APPROVED UNDER SPECIFICATION NO. AN-JC-48

WIRE & CABLE • DIE CASTINGS • PLASTICS • INDUSTRIAL THERMOMETERS

INTRICATE LARGE CASTINGS ...readily produced in DUCTILE IRON

DUCTILE IRON is a cast ferrous product that combines the *process advantages* of cast iron with many of the *product advantages* of cast steel.

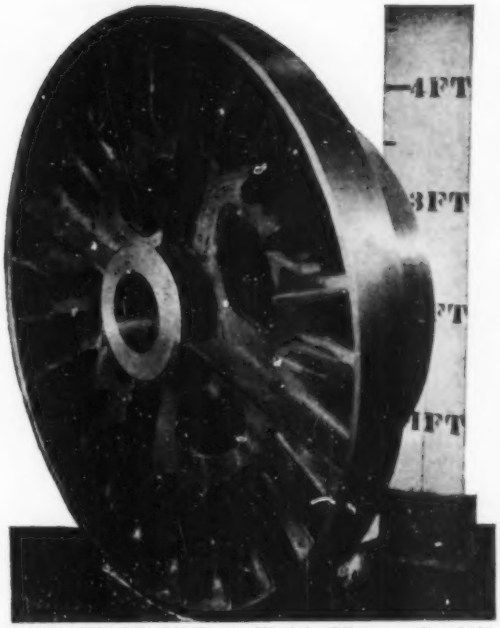
In less than two years, ductile iron has attained wide acceptance because it offers excellent castability, high mechanical properties, and good machinability. Parts cast in ductile iron show superior pressure tightness, high modulus and resistance to shock.

Typical current applications include chemical pots, compressor shells, cylinders for hydraulic presses, fly wheels, housing for electric power driven tools, large gears for coal mine equipment, vise jaws, and many other parts.

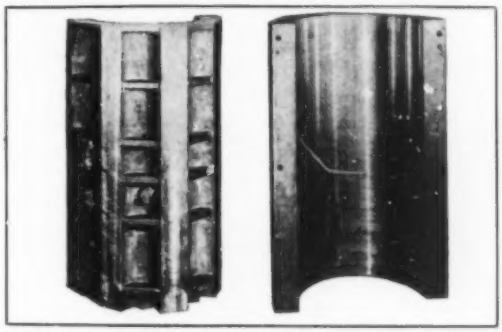
AVAILABILITY

Send us details of your prospective uses, so that we may suggest a source of supply from some 100 authorized foundries now producing ductile iron under patent licenses. Request a list of available publications on ductile iron...mail the coupon now.

ST. PAUL FOUNDRY & MANUFACTURING CO., St. Paul 3, Minn., cast this hydraulic head for a billet conditioner in ductile iron having 92,000 p.s.i. tensile strength, 67,000 p.s.i. yield point and 7.8% elongation.



STAVER FOUNDRY COMPANY, Virginia, Minn., produced this large hoist drum in ductile iron to meet requirements of toughness with strength, and wear resistance with good machinabilit[illegible].



PYOTT FOUNDRY & MACHINE CO., Chicago 7, Ill., produced these ductile iron castings for dies for forming 24" to 36" diameter pipe from steel plate of ¼" to ½" thicknesses. The finished tooling was done by the Vernon Allsteel Press Co. of Chicago. The dies are to be used in large presses that exert 18,000 tons pressure.

INCO

The International Nickel Company, Inc.
Dept. P.E., 67 Wall Street, New York 5, N. Y.

Please send me a list of publications on: **DUCTILE IRON**

Name.....Title.....

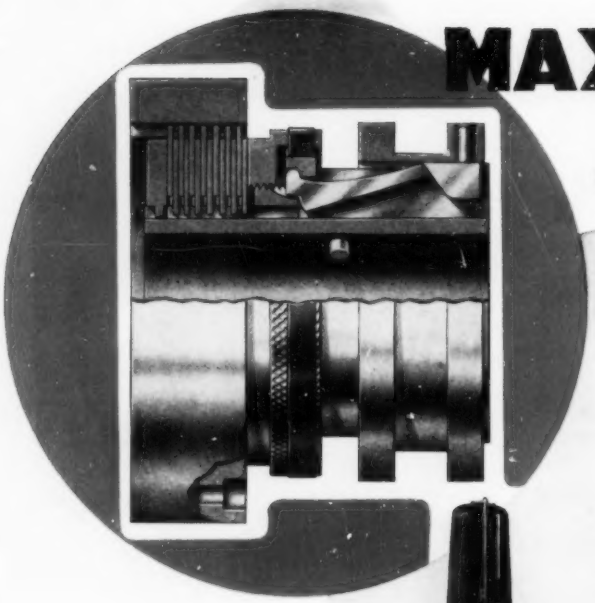
Company.....

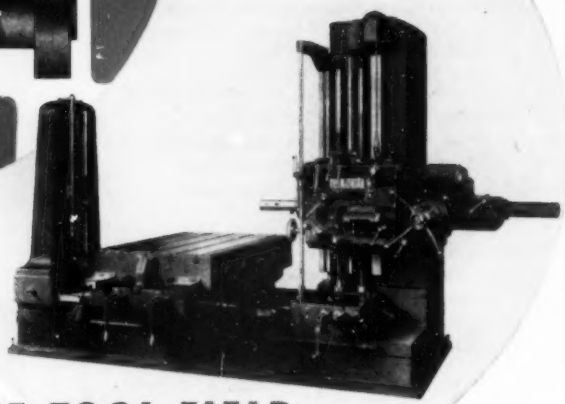
Address.....

City.....State.....

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

MAXITORQ
KEEPS GOOD COMPANY





. . . IN THE MACHINE TOOL FIELD

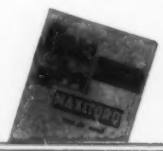
It is a pleasure to express our appreciation to the Cincinnati Gilbert Machine Tool Co. for their selection of our No. 25 Maxitorq Clutch as original equipment in their Gilbert Horizontal Boring, Drilling and Milling machines.

The multiple "floating disc" single Maxitorq Clutch (3 h.p. at 100 r.p.m.) is located on the initial shaft in the Unit Head, controlling the r.p.m. of the spindle.

Maxitorq Clutches are available in 8 standard sizes, fractional to 15 h.p. . . . single or double, wet or dry. "Floating discs" ride free in neutral, preventing drag, abrasion, heating. Clutch is completely assembled on the body, shipped ready to slip onto a shaft. All assembly, adjustments and take-down are manual. Varied Maxitorq Driving Cups may be ordered for specific needs.

Within its capacity there's no more compact or dependable clutch than Maxitorq. Check with our Engineers for solution of your problems in power transmission.

Send for Bulletin PE9, "Maxitorq Goes to Work"... showing 16 interesting installations by leading industrial users.



THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

Design Dept.:

Let's look at plastics in relation to all of these design, production and sales.

J.B.

And let's discuss our production costs.

Look at this.

Monsanto can help us.

Get in touch with them today.

"We overcame design, production, *and* sales problems when we scrapped habit-itis* – and discovered plastics," says J. W. Marcus, V. P., The Steel City Manufacturing Company, Youngstown, O., whose new syrup dispenser jar and Ownzak measuring faucet are molded of Lustrex by Continental Plastics Corp., Chicago.

*habit-thinking in design and materials engineering.

"We're making...and selling...our new dispenser better, faster, at lower cost...with plastics"

There are no less than *twenty-five* basic reasons why Monsanto's modern Lustrex styrene plastic replaced traditional materials in this new dispenser.

Among them: crystal-clear transparency for greater sales appeal . . . light weight combined with strength and toughness . . . lower materials costs by volume and fast, efficient one-shot molding, with little or no machining or finishing required.

These advantages – and others – might mean an improved product, production economies, or added sales for you. Remember, though, Monsanto produces a big *family* of plastics . . . *each* with its own special properties and characteristics. For expert help with your materials problems, call on the Monsanto Technical Council; or, for the names of competent molders and fabricators in your own area, write to the MONSANTO CHEMICAL COMPANY, Plastics Division, Room 2109, Springfield 2, Mass. Lustrex: Reg. U. S. Pat. Off.

MONSANTO CHEMICALS – PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

MONSANTO CHEMICAL COMPANY, Plastics Division,
Room 2109 Springfield 2, Mass.

☐ Please send me information on the big Monsanto family of plastics.
☐ Please send the name of plastics molders who can help me.

Name & Title _____

Company _____

Address _____

City, Zone, State _____

Redmond

MICROMOTORS

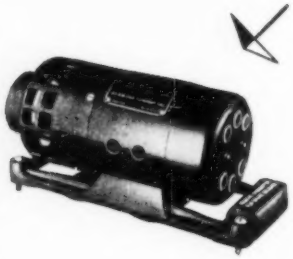
DYNAMOTORS, WINDSHIELD WIPERS

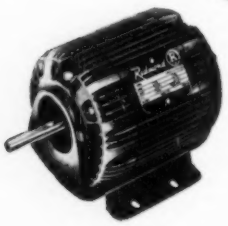
and other

SPECIAL EQUIPMENT

for

MILITARY REQUIREMENTS





Is your problem new and different? Do you need a product that suddenly requires high volume production . . . then check with Redmond.

Here's an organization that specializes in precision on a mass production basis — an active team of 3000 thoroughly trained personnel accustomed to building electrical rotating products by the millions, year after year. Here you'll find a capable engineering staff, easy to work with and ready with the right answers.

Take advantage of Redmond's experience, phone or write today.

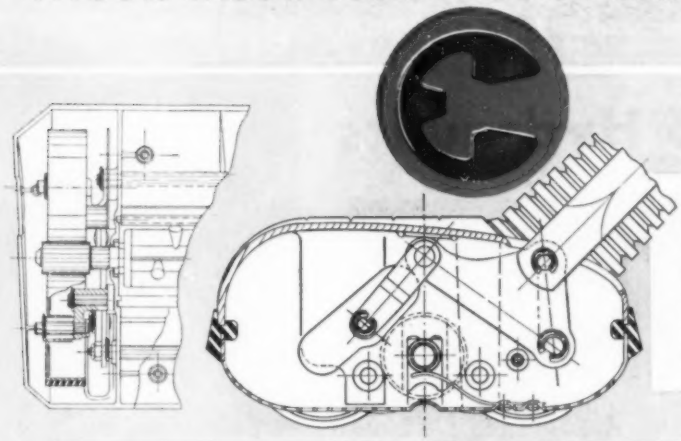
Redmond COMPANY, Inc.

REDMOND COMPANY, INC., Owosso, Mich., U.S.A. INDUCTION MOTOR SALES OFFICES: *Eastern Area: 420 Lexington Ave., New York 17, N. Y.; Central Area: Owosso, Michigan; Midwest Area: 332 S. Michigan, Chicago 4, Ill.; Southwest Area: 1330 N. Industrial Blvd., Dallas, Texas; Western Area: (Redmond Company of Calif., Inc.) 1260 S. Boyle Ave., Los Angeles 23, Calif.* **SERIES MOTOR SALES OFFICES:** *Owosso, Mich.* **OVERSEAS SALES OFFICES:** *420 Lexington Ave., New York 17, N.Y., cable address, REDISINC - NEW YORK.*

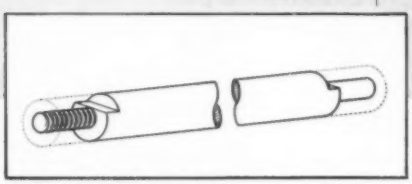
THE BIG NAME IN SMALL MOTORS

REDMOND

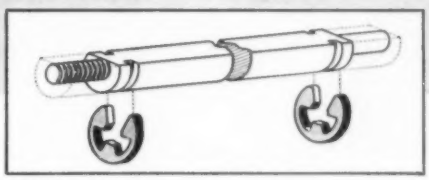
12 TRUARC RINGS SAVE 25% MATERIAL ...50% LABOR COSTS...50% ASSEMBLY TIME



With Waldes Truarc Retaining Rings, assembly in hard-to-reach places is easier, since there are no washers and bulky lock nuts. Smaller shafts can be used. Unit is smaller, lighter, more efficient!



CONVENTIONAL WAY: 2 round rods were required, milled down to D-shape. Difficulty of keeping flat surfaces in same plane caused rejects. Two separate threading operations to accommodate lock nuts.



TRUARC WAY: Truarc Rings allowed Lewyt Corporation to use two stock D-shape rods. No milling of shoulders. Simple screw machine operation cuts grooves for Truarc E-Rings, threads one end. Greater accuracy, fewer rejects.

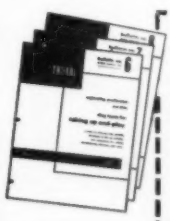
Using 12 Waldes Truarc E Retaining Rings in their new "101" Vacuum Cleaner nozzle brought the Lewyt Corporation, Brooklyn, N. Y. tremendous material and labor savings...eliminated 2 milling and 12 threading operations...made possible the use of stock extruded D-shaped rods...simplified maintenance. And with Waldes Truarc Rings unit is 15% lighter...10% smaller overall!

Redesign with Truarc Rings and you too will cut costs. Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better job of holding parts together.

Waldes Truarc Rings are precision-engineered... quick and easy to assemble and disassemble. Always circular to give a never-failing grip. They can be used over and over again.

Find out what Truarc Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

SEND FOR NEW BULLETINS



WALDES TRUARC RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,047; 2,382,948; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,840; 2,455,165; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,509,081 AND OTHER PATENTS PENDING.

Waldes Kohinoor, Inc., 47-16 Austel Place PN093
Long Island City 1, N. Y.

Please send Bulletins 6, 7 and 8—giving engineering specifications for all types of Waldes Truarc Rings.

Name_____

Title_____

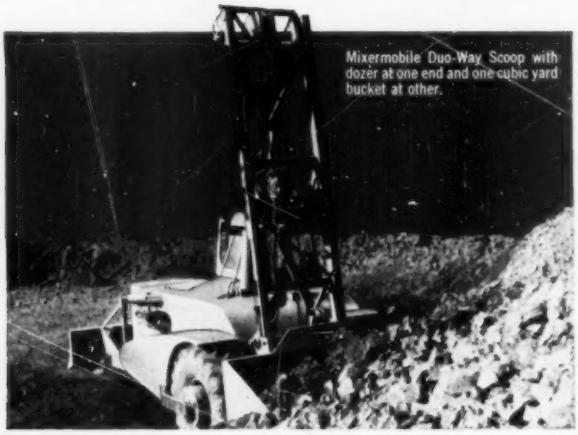
Company_____

Business Address_____

City_____ Zone_____ State_____

678

Versatile MACHINES USE *Versatile* VICKERS Hydraulics



Mixermobile Duo-Way Scoop with dozer at one end and one cubic yard bucket at other.

Vickers Hydraulics are versatile . . . they provide any motion or combination of motions, any amount of power at any distance. Control is fast, smooth, accurate and reliable. The heaviest mobile equipment can be put through the most precise operations with no more physical effort than it takes to flip a lever.

Hence, in designing versatile machines, manufacturers make large use of Vickers Hydraulics. These Mixermobile Units are representative . . . they are 100% Vickers equipped, offering the advantages of undivided responsibility and a nationwide organization. For information about the many ways that Vickers Hydraulic Pumps and Controls improve performance and cut costs on mobile type machinery, write for new Catalog M-5100 or get in touch with a Vickers application engineer.

VICKERS Incorporated • 1454 Oakman Blvd. • Detroit 32, Mich.
DIVISION OF THE SPERRY CORPORATION

Application Engineering Offices: ATLANTA • CHICAGO (Metropolitan) • CINCINNATI • CLEVELAND DETROIT • HOUSTON • LOS ANGELES (Metropolitan) • NEW YORK (Metropolitan) • PHILADELPHIA PITTSBURGH • ROCHESTER • ROCKFORD • ST. LOUIS • SEATTLE • TULSA WASHINGTON • WORCESTER

Engineers and Builders of Oil Hydraulic Equipment Since 1921

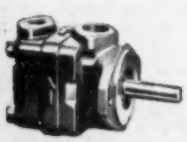
4498

More COST-CUTTING Applications of VICKERS HYDRAULICS

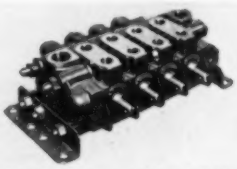
Mixermobile complete mobile concrete mixing and elevating plant.

MIXERMOBILE

Wagnermobile Model "C" Scoop, one machine for six jobs.



Vickers Balanced Vane Pumps feature automatically controlled radial and axial clearances that maintain high efficiency throughout long life.

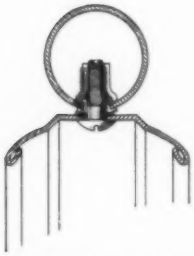


Vickers Multiple Unit Valves consist of individual operating valve sections, assembled in almost any combination for various hydraulic control functions. Provide precise positioning under actual operating conditions . . . unaffected by surges.

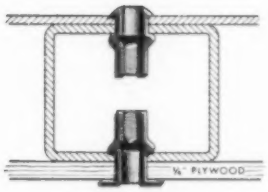
ASK FOR CATALOG M-5100
Vickers Hydraulics for Mobile Equipment

Vickers Steering Booster provides instantaneous, effortless hydraulic power for maximum maneuverability with heaviest loads on steering axle.

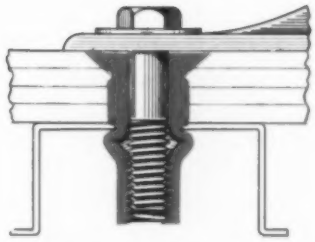
RIVNUTS solve tough fastening problems



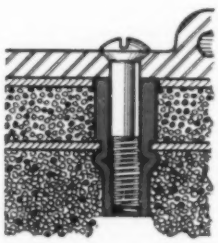
1 TO ATTACH A MUDGUARD to a bicycle's tubular frame, designers used a standard flat-head Rivnut. The correct radius was ground into the anvil of the heading tool, which curved the Rivnut head at the same time the bulge was formed. The still-intact Rivnut threads provided a firm anchor for the attachment screw.



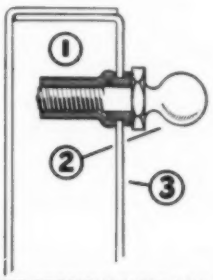
2 RIVNUT AT BOTTOM (above) fastens plywood walls to tubular steel sections in trailer. Large washer head and bulge in shank prevent Rivnut pulling through plywood or vibrating loose. Rivnut at top rivets steel sheet to opposite side of section. *One man* can install a Rivnut from one side of work *in two seconds*.



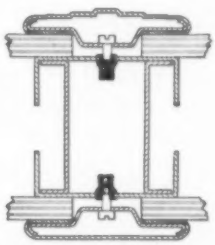
3 BUS DESIGNERS used Rivnuts—*the only one-piece blind rivet with threads*—to fasten seats to plywood floor board. Heading tool upset Rivnut, forming bulge under floor board. Splines on Rivnut shank took care of torque. At least 6 Rivnut threads remained clean to grip attachment screw. Many man-hours were saved in assembly.



4 WALK-IN REFRIGERATOR uses special-type Rivnuts to attach hinges to door made of steel sheets and sponge insulation. Spacer head allows upsetting of Rivnuts deep in door. Rivnuts form compression fit which provides positive sealing. Clean threads take hinge attachment screws. Closed-end Rivnuts available for special sealing jobs.



5 THREE PROBLEMS WERE SOLVED by Rivnuts in this kitchen cabinet door. (1) Rivnut was installed from one side only, (2) it furnished at least 6 clean threads for attaching knob, and (3) it was installed *after* enameling without marring the finish. Rivnuts improved product quality, saved many man-hours on the job.



6 THE PORCELAIN STEEL WALLS of this pre-fabricated building are securely fastened, yet easily removable for moving or repairs—thanks to Rivnuts. Installation is made by one man from one side of studding. Rivnuts require only very small hole, provide wide bearing surface. Cap screws threaded into Rivnuts attach walls.

B.F.Goodrich

RIVNUTS

The only one-piece blind rivet with threads

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Have a fastening problem? Get the help of Rivnut Engineers. Ask also for free demonstrator that shows with motion how Rivnuts work. Explains construction. Gives applications. Write to The B. F. Goodrich Co., Dept. PE-91, Akron, Ohio.

Cork-and-Rubber Gasket Materials made to meet government specifications

There is an Armstrong material made to meet each of the 6 types included in the principal government specification covering cork-and-rubber gasket materials. These materials are listed below. For detailed information about these compositions, please see Sweet's file for product designers or call the nearest Armstrong office listed below.

Government Specification		Armstrong Material
MIL-G-6183	Type I Soft	NC-709
	Type I Medium	NC-710
	Type I Firm	NC-711
	Type II Soft	DC-167
	Type II Medium	DC-100
	Type II Firm	DC-113
MIL-T-6841		DK-153 or RK-304S
MIL-T-6747		DK-149

New cork-and-rubber compounds. Armstrong's Research Laboratories are ready to develop cork-and-rubber materials to meet new military requirements as they arise. Please discuss your needs with your nearest Armstrong representative . . . or write.

Cork compositions. There is an Armstrong Cork Composition made to meet each of the classes under Federal Specification HH-C-576, as well as each of the grades under specification MIL-C-16090.

Synthetic rubber compounds. Armstrong manufactures highly specialized synthetic rubber compounds for certain critical applications. For example, Armstrong makes a rubber washer that meets the requirements of the aircraft fuel nozzles made under MIL-N-4180.

Armstrong's Gasket Materials

Send for this gasket manual

You'll find up-to-date information on current government specifications and tentative SAE-ASTM specifications in "Armstrong's Gasket Materials."

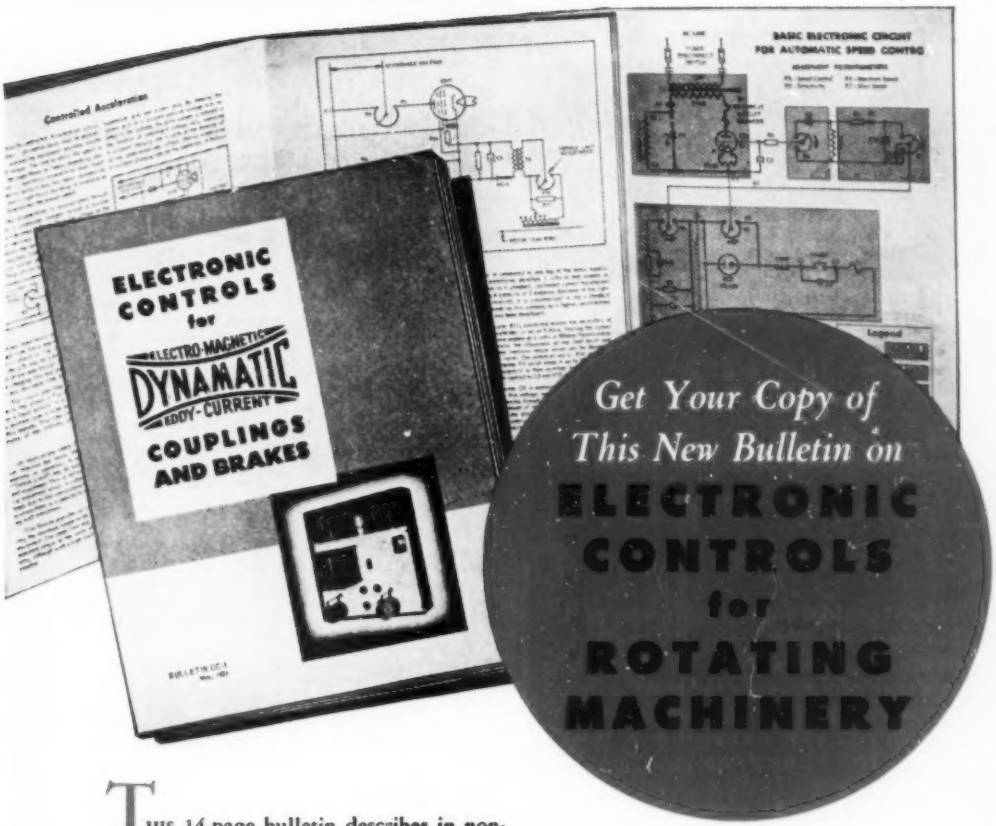
You'll find, too, in this 24-page manual, a lot of helpful information on the design and use of gaskets. Included are discussions of subjects such as designing gaskets to reduce cost . . . practical tolerances for resilient gaskets . . . designing flanges for efficient sealing, and many others.

See "Armstrong's Gasket Materials" in Sweet's file for product designers. For a personal copy of this manual, write to Armstrong Cork Company, Gaskets and Packings Dept., 7109 Arch St., Lancaster, Pa.

NEW 1951 EDITION

Your nearest Armstrong Industrial Division office

ALBANY 10, N. Y., 64 Northern Boulevard, Telephone: 4-0131 • BOSTON 16, MASS., 131 Clarendon Street, Telephone: COpley 7-2490 • CHICAGO 54, ILL., 13-136 Merchandise Mart, Telephone: DElaware 7-0500 • CINCINNATI 2, OHIO, Temple Bar Building, 138 E. Court Street, Telephone: PArkway 3220 • CLEVELAND 15, OHIO, 209 Hanna Bldg. Annex, Prospect Ave. and E. 14th Street, Telephone: MAin 7900 • DETROIT 26, MICH., 10th Floor, Free Press Building, 321 Lafayette Avenue, West, Telephone: WOodward 3-5670 • GREENVILLE, S. C., 33 Norwood Place, Telephone: Greenville 3-5320 • LOS ANGELES 15, CALIF., 719 Bendix Building, 1206 Maple Avenue, Telephone: RICHmond 0286 • NEW YORK 16, N. Y., 295 Fifth Avenue, Telephone: MUrray Hill 4-6900 • PHILADELPHIA 2, PA., Robinson Building, Fifteenth and Chestnut Streets, Telephone: LOcust 4-4290 • ST. LOUIS 3, MO., 1205 Olive Street, Telephone: CHestnut 1757 • In Canada: Armstrong Cork Canada Limited, 6911 Decarie Boulevard, Montreal, Quebec, Telephone: ATlantic 4733.



THIS 14-page bulletin describes in non-technical terms the basic electronic circuit employed in the control of Dynamatic Eddy Current equipment —power couplings, drives, brakes. The information presented will be of interest to anyone engaged in the operation and maintenance of Dynamatic Devices or control equipment.

The text is thoroughly illustrated with simplified hook-up diagrams. If you are interested in modern electronic speed control, write for your copy.

CONTENTS

Elements of the Dynamatic Drive
Description of Electronic Control
Special Control Circuits
- **Pre-set Multiple Speeds**
- **Threading**
- **Inching or Jogging**
- **Controlled Acceleration**
- **Torque Limit**
- **Eddy Current Braking**
- **Mutuatrol**
- **Cascading**
- **Speed Matching of Processing Equipment**
- **Parallel Excitation Controls**

DYNAMATIC CORPORATION • KENOSHA WISCONSIN

Subsidiary of EATON MANUFACTURING COMPANY, Cleveland, Ohio

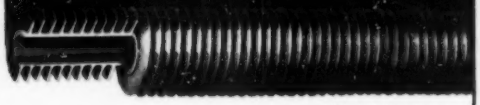
Dynamometers • Oil Well Draw-Works Brakes • Adjustable-Speed Couplings • Eddy-Current Brakes
Ajusto-Spedes • Shovel Clutches • Press Drives • Lift Truck Clutches • Electronic Controls

BUILDING A HEAT TRANSFER UNIT?

Do you know about the many advantages of Wolverine Trufin*?

When considering the designing and building of such units as coolers, heaters, interchangers, condensers or other components for heat transfer work, be sure to look into the extraordinary advantages that Trufin can bring you.

Would you like a copy of our booklet that gives much helpful information about this unique finned tube? Sent upon request on your stationery.



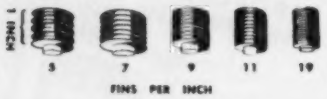
*Reg. U. S. Pat. Off.

WOLVERINE TUBE DIVISION
Calumet & Hecla Consolidated Copper Company
INCORPORATED
Manufacturers of seamless, non-ferrous tubing
1415 CENTRAL AVENUE • DETROIT 9, MICHIGAN

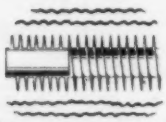
Wolverine Trufin and the Wolverine Spun End Process available in Canada through the Unifin Tube Co., London, Ont.

Here are a few reasons why Wolverine Trufin* should be used in your heat transfer development

Trufin is space-saving. As an example: the equivalent outside surface area of a nineteen-inch length of plain tube of ⅝" diameter can be obtained in just one inch length of Trufin of the same diameter. That reflects itself in increased capacity within the present space; or existing capacity in space of much smaller proportions.



Many Sizes and Alloys. Trufin is available in 5, 7, 9, and 11 fins per inch with inside diameters from ⅛" to 1". Also available in 19 fins per inch (held to root diameter specifications). Information regarding specific alloys and bi-metal upon request.



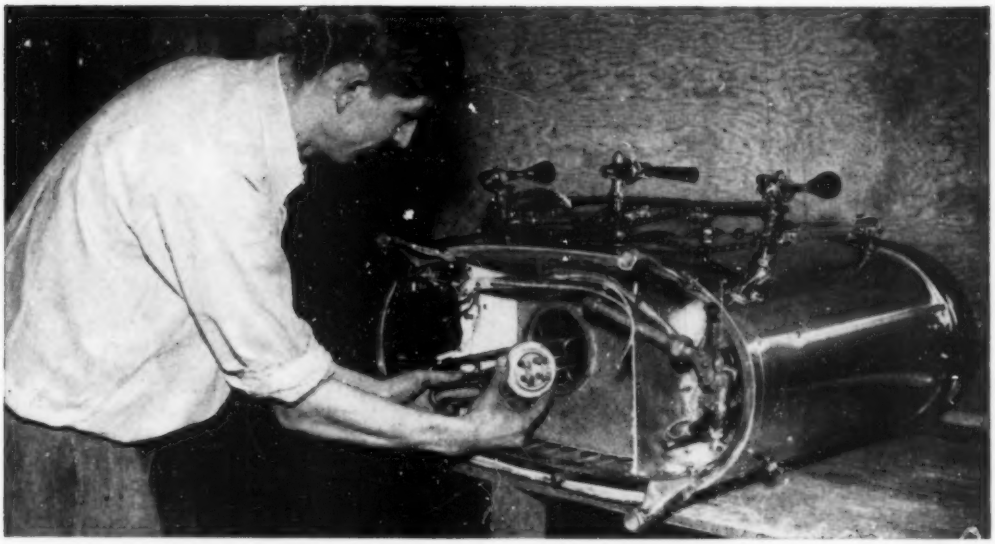
Wear and Endurance. Because the fins are integral with the tube itself, the tube will withstand vibration and sudden temperature changes. It cannot be impaired as easily as other types of finned tube by corrosive conditions. This, obviously, makes for long wear and less frequent replacement.

Easy Fabrication. Trufin can be formed into practically any shapes much easier than plain tube can, since the fins act as a support to the exterior. The tube does not collapse. Shorter bends can be made without the use of a mandrel inside and support blocks outside.

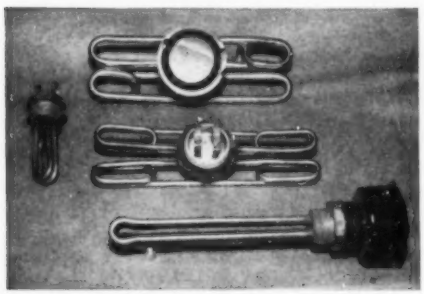
Connections Easily Made. Fins need not be stripped from Trufin when making connections because the inside diameters of Trufin are held to specifications. Connections can be made with standard tube by inserting and brazing. This represents much saving of time and materials.

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
Sales Offices in Principal Cities

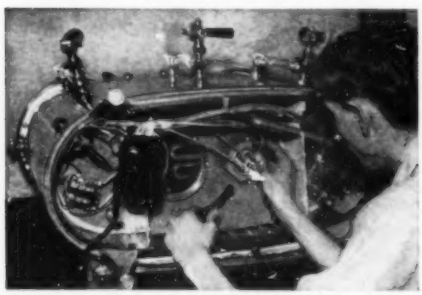
Export Department, 13 E. 40th Street, New York 16, N. Y.



1 Installation of the Calrod heater in a "Supermatic" coffee urn is a matter of minutes. The operator merely inserts the proper heater . . .



2 . . . which he has selected from the four standard types of Calrod immersion heaters which Superior stocks and uses exclusively . . .



3 . . . locks it into place, connects it up, and it's ready to provide the accurate, reliable heat so necessary for brewing coffee with that "Extra Goodness that brings customers back."

Calrod* Heaters Are Easy to Install

require little maintenance and no post-installation servicing, reports Superior Tea & Coffee Co.

MANY MACHINERY MANUFACTURERS, like Superior, are improving their process equipment with "built-in" electric heat. Fast, accurate, dependable heat . . . where they want it, when they want it, and in the amount they want . . . with G-E Calrod heaters.

Whether your application is heating liquids, surfaces, air, pipelines, or melting soft metals, there is a G-E Calrod heater to do the job. And the recommendations of a G-E Heating Specialist will save you money the way they saved for Superior.

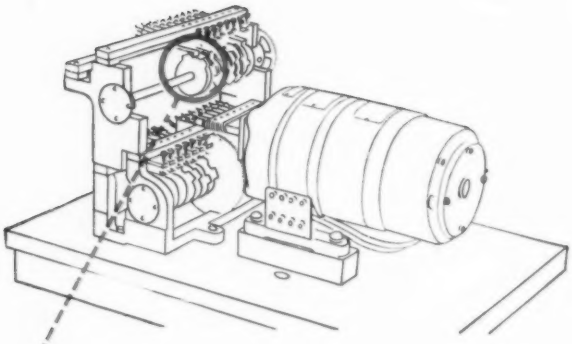
When you design for mass production, remember, Calrod heaters are easy to install and require little maintenance. Stock them and save on quantity purchases.

*Registered Trademark

You can put your confidence in—

GENERAL ELECTRIC

720-44



Cams of Du Pont nylon plastic wear longer

provide more accurate timing in telephone interrupters

NYLON CAM (a) is mounted on a shaft, driven by an electric motor. This turns slowly—from ½ to 15 r. p. m. Each cam bears specific contours which determine signals. When cam is pressed against nylon insert (b), the circuit closes, providing desired signal. Nylon parts molded by Victory Plastics Co., Hudson, Mass., for Holtzer-Cabot, Boston.

These revolving cams of Du Pont nylon plastic regulate the timing of busy signals and coded rings for your telephones. They do this by pressing against, then releasing, a nylon insert on a spring, which, in turn, closes and opens an electrical circuit. The nylon parts replace an intricate metal assembly, providing Holtzer-Cabot, the manufacturer, with interrupters that perform more accurately, last longer.

The nylon cam is supplied by the molder in the form of a blank, injection-molded to standard inside and outside diameters. The contours are then machined to meet signal requirements of individual exchanges. This vastly simplifies the manufacturing job, since the former part involved about 40 machining operations.

Smooth performance of the nylon parts gives more accurate control of timing pulses, measured in hundredths of seconds. What's more, they showed no sign of wear after accelerated tests equivalent to 3½ years of normal service. These tests indicate that new units with nylon cams and inserts will far outlast former assemblies.

Du Pont nylon plastic is finding many uses as an engineering material. It may pay you, as it did Holtzer-Cabot, to investigate its properties for future application.

Demand for nylon currently exceeds supply. However, we will gladly discuss the availability of experimental quantities for development work. For additional information on nylon and other Du Pont plastics, write:

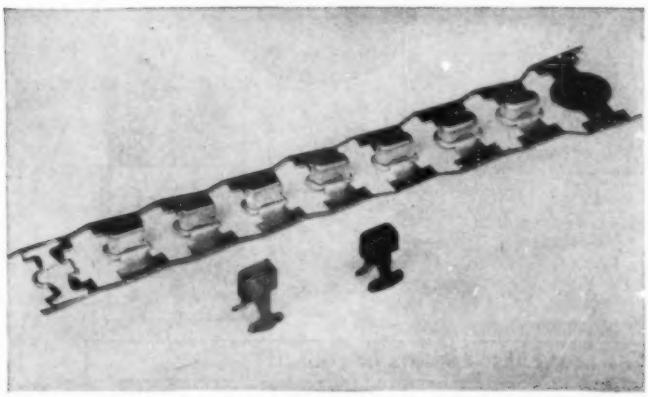
E. I. du Pont de Nemours & Company (Inc.)
Polychemicals Department, District Offices:
350 Fifth Avenue, New York 1, New York
7 S. Dearborn St., Chicago 3, Illinois
845 E. 60th St., Los Angeles 1, California

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY
Polychemicals
DEPARTMENT
PLASTICS • CHEMICALS

BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

"Bridgeport" MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL



Showing progressive operations in the manufacture of clamp for telephone headset jack. Courtesy, Connecticut Telephone and Electric Corporation, Meriden, Connecticut.

Careful Planning Before Production

Avoids Trouble in Deep Drawing Brass

As in all things, experience in the deep drawing of brass and other copper-base alloys is the best teacher. The reshaping of flat metal into various cup-shaped objects on an efficient production basis is an intricate procedure, and involves skills and know-how. It is, therefore, wise to investigate the problem carefully before attempting to go into production. Help for the determination of the proper alloy for the particular job, and often suitable fabricating techniques as well, can be obtained from our Metallurgical Laboratory and from our literature such as Bridgeport's "Technical Handbook."

The illustration shows the progressive operations used in the production of a clamp for a telephone headset jack. This involves the deep drawing of a rectangular cup, which is not easy. Secondary blanking operations on the bottom of the cup and the formation of the brackets are shown in the small samples in the foreground. Considerable experimental work was done and further developments of the tools were necessary, which involved making two draws to obtain sufficient depth of cup. It was also found advisable to increase the width of the strip metal. The change to a lard oil lubricant was also helpful.

Factors to Consider

The following check-list should be helpful in demonstrating the various points which must be carefully considered before drawing work is actually begun.

1. *Stock*—The flat metal must be wide enough to compensate for contraction of the blank during cupping. Alloy, gauge, tolerance requirements; temper; diameter of arbor are essential.

2. *Punch and Die Radii*—Normal die radius is between 5 and 10 times the thickness of the metal. Too large or too small a die radius may cause trouble.

3. *Die Finish*—Careful polishing of the die is important, since there is a great deal of motion between the metal and the die. Dies should be lapped in the direction of metal flow.

4. *Blank Holder Pressure*—If the blank is not held tightly, the circumferential forces in the perimeter of the blank will produce wrinkling. If blank holder pressure is too great, thickening of the blank will be prevented, and may result in fracturing of the cup.

5. *Diameter Reductions*—In the production of a normal cup for redrawing, the most satisfactory diameter reduction ranges between 40 and 46%. This produces a cup about equal in height and diameter. In making greater reductions, difficulty is encountered in regulating blank holding pressures, and there is danger in the softer alloys of fracturing the cup. In progressive die operations, such as the clamp described above, successive redraws after the cupping operation are held to approximately 15%, since there are no intermediate anneals.

6. *Lubricants*—A lubricant must be used to reduce friction to a minimum and prevent metal-to-metal contact. It must first wet the surface thoroughly, and have sufficient body to stay in place under forming and drawing pressure. The choice of lubricant for a job depends on several factors, including the severity of work, equipment used, production run, means of application and cost. Usually simple soap solutions are satisfactory, but lard oils, vegetable oils and other lubricants are often used.

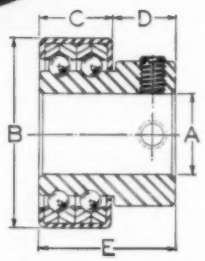
7. *Metal Surface Finish*—This is important especially in deep drawing operations such as in progressive and eyelet types of work.

This list is intended simply to point out some of the factors influencing success in drawing. Specific problems naturally arise in every individual job. Bridgeport will be glad to help customers with these problems by sharing its vast reservoir of experience acquired in the production and fabrication of copper-base alloys. (6831)

"Commercial" Ball Bearing Data

TYPE "A" *UNGROUND* DOUBLE ROW BEARINGS WITH SET SCREWS

(Also available in Metric Dimensions)



APPLICATION: Wherever low speeds are combined with high loads. Example: plating and tumbling barrels.

FEATURES: Close bore tolerance of +.004", —.000"; carburized race rings of high-grade, low-carbon steel, hardened and tempered; high quality balls.

DIMENSIONS IN INCHES—RATINGS IN POUNDS

Bearing No.	Bore A +.004" —.000"	O. D. B +.002" —.002"	O. R. C	I. R. E	Ext. D	Balls		Load Rating at 600 RPM
						No.	Size	
CS 2873X1	1-1/8	2-5/8	1-1/64	1-57/64	7/8	46	1/4	360
CS 2871	1-3/16	2-5/8	1-1/64	1-57/64	7/8	46	1/4	360
CS 2749	1-1/4	2-5/8	1-1/64	1-57/64	7/8	46	1/4	360
CS 2674	1-7/16	2-3/4	1-7/64	1-55/64	3/4	40	5/16	485
CS 2713	1-11/16	3-3/32	1-11/64	2-3/64	7/8	42	11/32	620
CS 2870	1-15/16	3-3/8	1-15/64	2-7/64	7/8	52	5/16	610

NOTE: For load ratings at other speeds, multiply the rating at 600 rpm by the following factors:

50 rpm	100 rpm	300 rpm	900 rpm
2.50	1.80	1.30	.82

Schatz Ball Bearings are designed to give optimum friction-free performance at low initial cost. Use them wherever speed and load conditions permit: to replace costly precision bearings not required by operating conditions; or to save expensive machining and assembly time now required for sleeve and plain bearings.

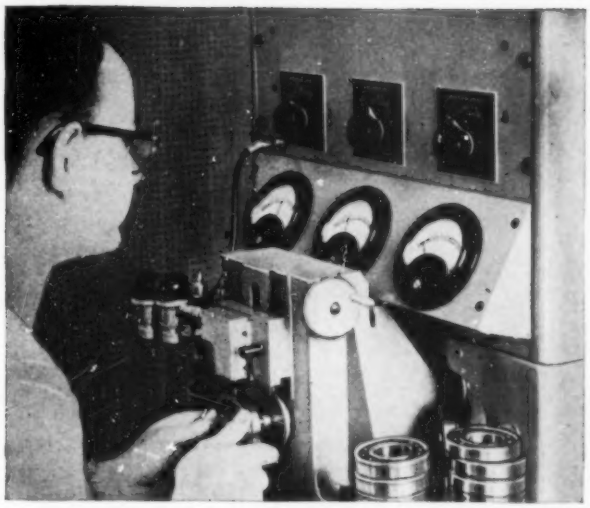
SEND FOR CATALOG 11. It contains detailed drawings and specifications of all Schatz Ball Bearings. Study the load capacity tables in this factual book. Chances are you'll see where low initial cost of Schatz "Commercials" can save you money in volume applications—with no sacrifice in operating efficiency. And where standard type "Commercials" aren't adaptable to your needs, Schatz makes a variety of special designs and types that can't be duplicated from any other source.

SCHATZ
"Commercial"
BALL BEARINGS

If You Have a Friction Problem
Let Schatz Engineers Design it Away

THE SCHATZ MANUFACTURING COMPANY
6758 Fairview Avenue · Poughkeepsie, New York

Beating Friction...



...with Precisely Tested Ball Bearings

Modern automobiles—like modern machine tools, agricultural and textile machines—are high-performance products in which ball bearings are vital. Federal—a 35-year "original-equipment" bearing supplier to the automotive field—has always been in the forefront in anti-friction ball bearing design. Year after year, Federal skills have been utilized by performance-conscious engineers to improve rotating products.

At Federal, quality is a known quantity. Federal makes certain of that by subjecting *every* ball bearing to a complete checkup before shipment to make certain that dimensions and surfaces are accurate. Special testing machines actually "listen" to bearings under operating conditions—for quietness is a prime measure of ball bearing precision.

Federal's testing is done in soundproof booths, with gages that duplicate those used in the shop, with electronic devices that check surface irregularities. That's why your engineers can be *sure* of the performance of Federal ball bearings in your products.

Every Federal ball bearing is a product of the combined skills of IMAGINATIVE RESEARCH • ADVANCED ENGINEERING • ALERT MANUFACTURING • RIGID QUALITY CONTROL • SUPER-PRECISE TESTING.

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, NEW YORK

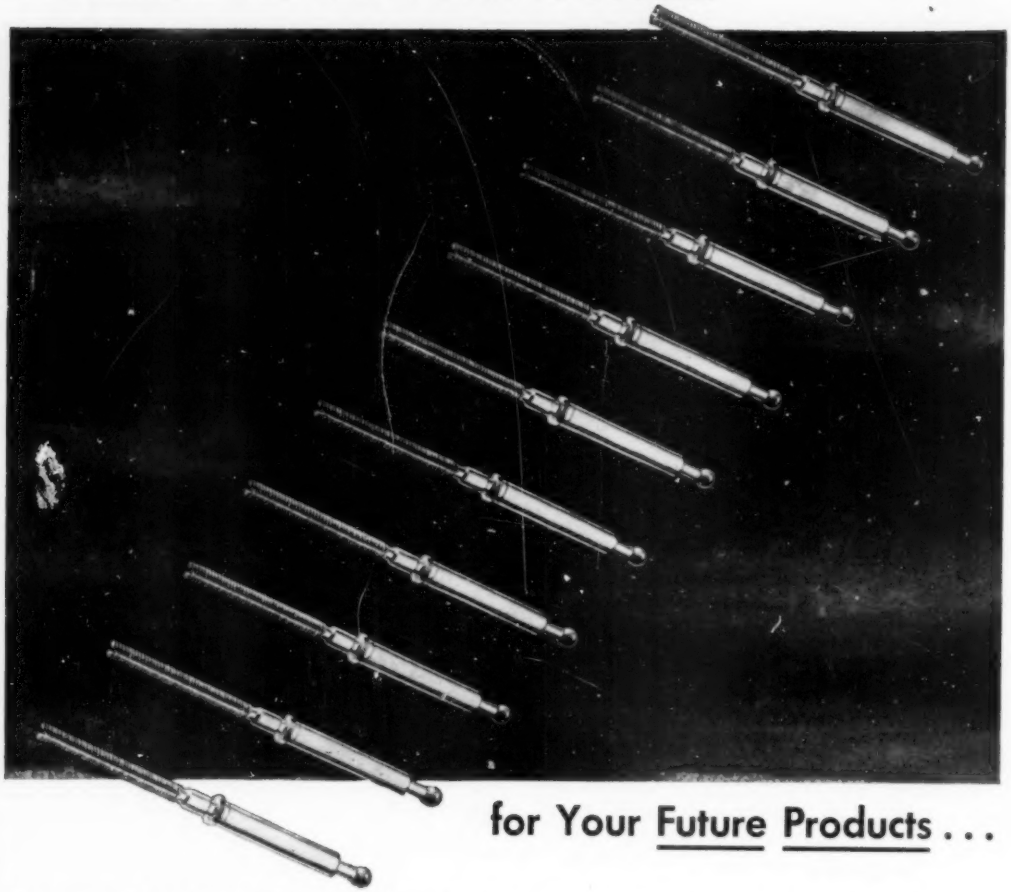
Makers of Fine Ball Bearings

Federal BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

Quality since 1908

A Stainless Job That Points to Success



for Your Future Products . . .

When your talk gets around to Stainless for your own future products, this Stainless job points the way to giving you extra advantages. It shows why it pays to consider Carpenter for Stainless that will do the unusual.

Take a second look at this job, for example. Tolerances were close, and had to be "on the nose" every time. Finishes had to be "perfect", to insure accurate operation. And like all other precision jobs, the parts had to be produced with minimum rejects.

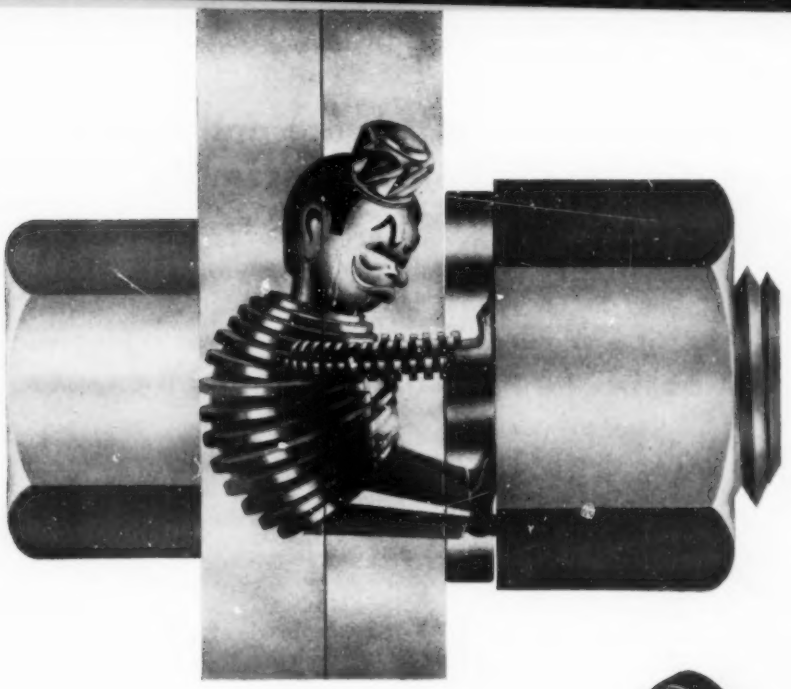
In today's planning for the future, if you have the problem of recommending a Stainless that will give you something extra in performance or in production, it's a good idea to call Carpenter. Put Carpenter's experience with Stainless to work on *your* jobs.

Helping engineers get improved or unusual results with Stainless is our favorite job. From the time the first free-machining Stainless was invented in Carpenter's laboratories, we have been developing new Stainless Steels and improving old ones. They are described in "Working Data for Carpenter Stainless Steels". Let us know if you would like a personal copy.

The Carpenter Steel Company, 117 W. Bern St., Reading, Pa.
Export Department: Carpenter Steel Co., Reading, Pa.—"CARSTEELCO"

DON'T WAIT... COOPERATE!
The U.S. Needs Your Steel Scrap, Now

Carpenter
STAINLESS STEEL
takes the problems out of production



Automatic "TAKE-UP" between bolt head and nut

- Wear and looseness are certain to develop in bolted assemblies as a result of service conditions.
- Reliance Spring Lock Washers automatically exert reactive pressure to compensate for such a condition and maintain tension in the bolted parts, thus minimizing wear.
- They also serve as hardened thrust bearings, permitting greater applied tightening torque.
- There's a type of Reliance Spring Lock Washer for every fastening application and requirement. Write for Bulletin W50.

RELIANCE *Spring* **LOCK WASHERS**

EATON MANUFACTURING COMPANY, RELIANCE DIVISION

OFFICE AND PLANTS • MASSILLON, OHIO

SALES OFFICES: NEW YORK • CLEVELAND • DETROIT • CHICAGO • ST. LOUIS
SAN FRANCISCO • MONTREAL

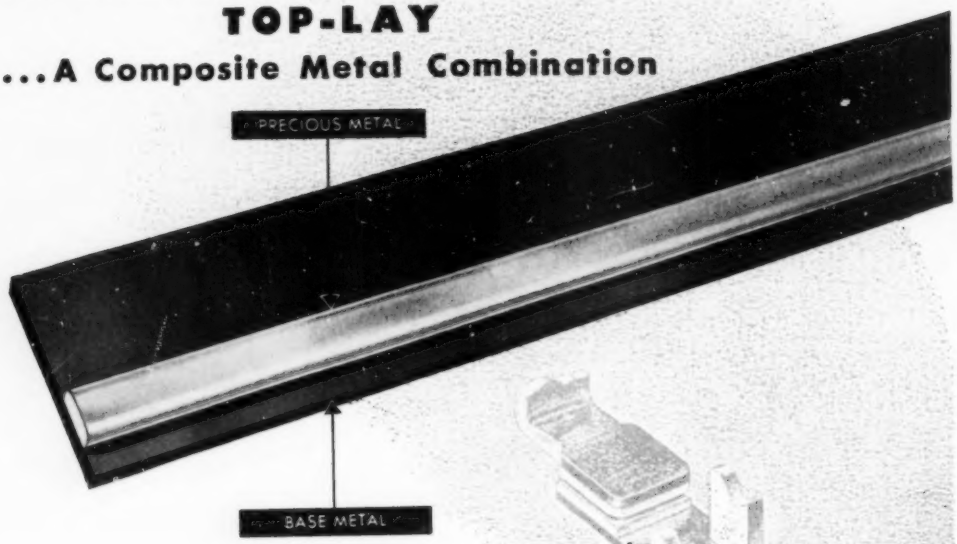
In Canada: Eaton Automotive Products, Ltd., London, Ont.

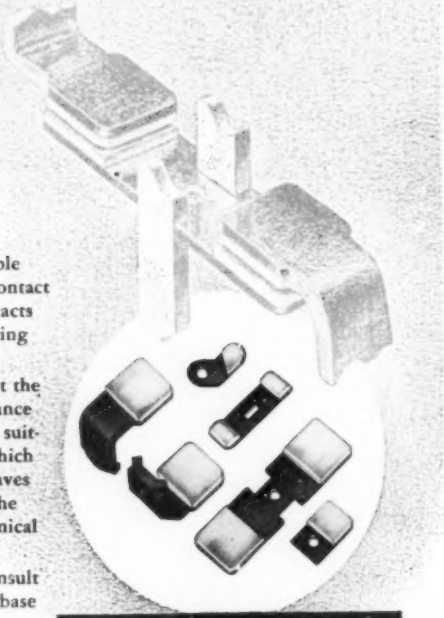
PROBLEM:

How to Get Higher Performance and Longer Wearing Qualities in Contact Assemblies

GENERAL PLATE:

Meets the Specified Requirements with TOP-LAY ...A Composite Metal Combination





Manufacturers of electric motor starters had frequent trouble with contact assemblies which were made by brazing the contact to the base metal carrier. This method results in annealed contacts and carriers which in turn means lack of strength, poor wearing qualities and short contact life.

General Plate's Top-Lay contacts and contact material meet the engineering specifications by providing the higher performance necessary. Made by cladding silver or precious metal strip to suitable base metal, Top-Lay is cold worked by profile rolling which gives it a hard, long-wearing surface. In addition, Top-Lay saves on fabrication costs as it is easily blanked and formed to the required shape. (For information on Top-Lay write for Technical Data Bulletin #714.)

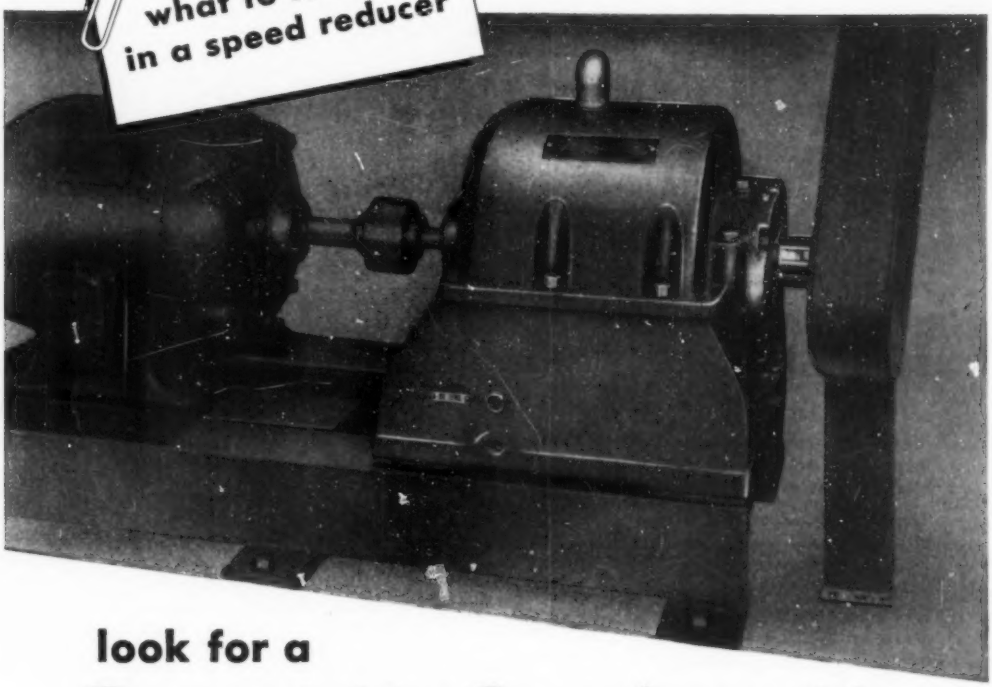
No matter what your metal problem, it will pay you to consult General Plate. Their vast experience in cladding precious to base metals, or base to base metal combinations can overcome your problems . . . often reduce costs as well.

General Plate Products include . . . Precious metals clad to base metals, Base metals clad to base metals, Silver Solders, Composite contacts, buttons and rivets, Platinum fabrication and refining, Age-hardenable #720 Manganese Alloy.

Have You a Composite Metal Problem? General Plate can solve it for you

GENERAL PLATE
Division of Metals & Controls Corporation
19 FOREST STREET, ATTLEBORO, MASS.

what to look for in a speed reducer



look for a

Dependable Gear Assembly

Tough, impact-resisting gears are the foundation for the dependable operation of Westinghouse Speed Reducers. Each gear is made from BPT Taper-Hardened Gear Steel, combining carefully selected material with an exclusive Westinghouse heat-treating process. Result is gearing with a hard, wear-resistant surface that tapers evenly to a tough, ductile core. Teeth will not chip, crack or spall.

Further dependability is provided by the *accuracy* of Westinghouse Gears. Teeth are cut by the hobbing process—recognized as the most accurate method of gear cutting. Tooth contours are precise and highly finished. Operation is smooth and quiet. The single helical design distributes load evenly, with uniform tooth deflection—large tooth contact area—long life with minimum wear.

You get such a dependable gear assembly in the new Westinghouse "DB" Speed Reducer pictured above. This concentric shaft, split housing-type speed reducer fills the bill where floor space is limited. Construction permits straight-line mounting of speed reducer and prime mover.

There's a Westinghouse product to meet each of your gearing requirements — speed reducers, gearmotors, high-speed units, open gearing. Contact your Westinghouse representative for a copy of Descriptive Bulletin 3700-ISR. Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania.

J-07502

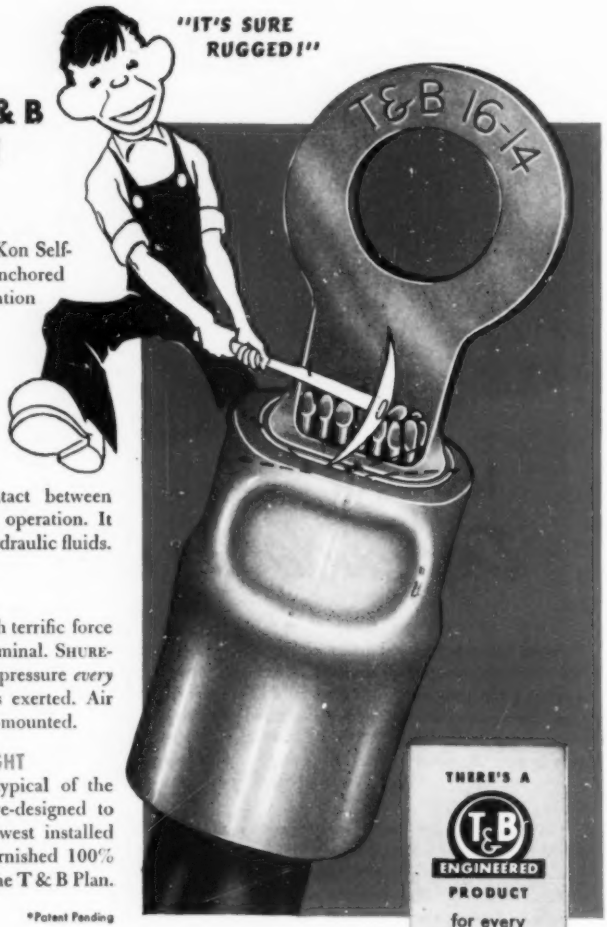
YOU CAN BE SURE... IF IT'S
Westinghouse
GEARED DRIVES

INSULATION STAYS PUT in the toughest service

. . . when you use T & B Sta-Kon® Self-Insulated Terminals*

Nylon insulation on these new T & B Sta-Kon Self-Insulated Terminals is press-fitted and anchored by flaring terminal barrel. Staking operation keys it in place to *stay*.

These new components end the risk of shorts between closely-mounted terminals. Metallic portion retains all the proved advantages of the Sta-Kon design—high conductivity, permanent grip. Lightweight nylon insulation prevents metal-to-metal contact between terminals . . . *without* an extra insulating operation. It withstands action of gasoline, naphtha, hydraulic fluids. It's *color-coded* for quick identification.



SIMPLE, SURE ASSEMBLY

One operation stakes terminal to wire with terrific force . . . holds wire insulation firmly inside terminal. SHURE-STAKE Hand Tools apply 1-ton staking pressure *every time*—jaws can't open till full force is exerted. Air tools available too—hand-held or bench-mounted.

ENGINEERED RIGHT...DISTRIBUTED RIGHT

Sta-Kon Self-Insulated Terminals are typical of the many T & B quality fittings recently re-designed to give you outstanding performance at lowest installed costs. Like all T & B fittings, they're furnished 100% through local T & B distributors under the T & B Plan.

*Patent Pending

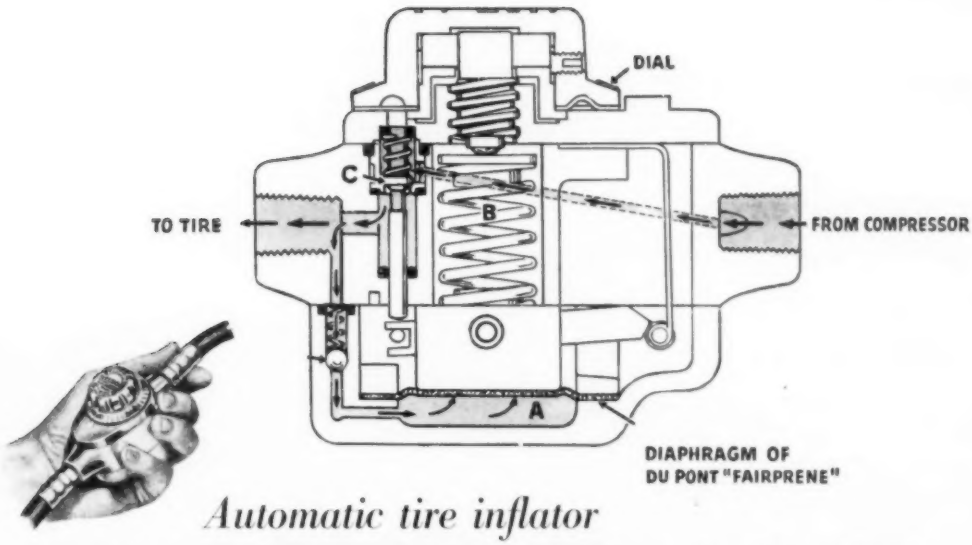
THERE'S A T&B ENGINEERED PRODUCT for every wiring job in the complete T & B line of fittings for all conductors and raceways.

THE THOMAS & BETTS CO., INCORPORATED

16 Butler Street, Elizabeth 1, New Jersey

MANUFACTURERS OF ELECTRICAL FITTINGS SINCE 1898
ORIGINATORS OF SELF-INSULATED SOLDERLESS TERMINALS IN 1935

Our Field Design Engineers are ready to help you on special fittings problems. Ask your nearest T & B Distributor to arrange to have one get in touch with you.



Automatic tire inflator

FLIPS ITS OWN SWITCH WHEN JOB IS DONE

LONG-WEARING DIAPHRAGM MADE OF "FAIRPRENE"* SERVES AS VITAL "NERVE" IN ACCURATE, SELF-OPERATING TIRE INFLATOR

THIS TIME-SAVING instrument for service stations, manufactured by the Nelson Specialty Corp., San Leandro, Calif., inflates tires to prescription. Like many other modern devices that function by means of a diaphragm, the Nelson Automatic Tire Inflator depends, for its long life, on the toughness, flexibility and durability of Du Pont "Fairprene" Coated Fabric.

Basically, here's how the Nelson Automatic Tire Inflator works: Pressure in the diaphragm chamber (A) equalizes with tire pressure. If this pressure is lower than the dial setting, regulator spring (B) pushes diaphragm head down, causing valve (C) to open. When the tire pressure reaches prescribed level, diaphragm head and cam keep valve closed.

In diaphragms such as the one above, as in hundreds of other industrial applications, Du Pont "Fairprene" is preferred for many reasons: it is tough . . . yet light in weight. It resists gasoline, oil, grease, kerosene, aging in air or oxygen. And "Fairprene" stays flexible in both high and low temperatures . . . has low permanent set and drift.

Technical Help for You

Du Pont engineers are eager to help you evaluate "Fairprene" for designing new products, or for improving your present products or manufacturing methods. They'll gladly work with you in engineering special grades of "Fairprene" to meet *your specific needs*. For prompt assistance, fill out and mail the coupon below. Do it today!

New "Teflon"† Coated Glass Fabrics, Tapes and Laminates

Outstandingly versatile new material for electrical industries. Made from woven glass fabrics coated with polytetrafluoroethylene.

Although, at present time, "Teflon" products are subject to allocation by the National Production Authority, limited experimental quantities are available.

A FEW PROPERTIES: high and low temperature resistance (may be used continuously at 200°C.), fine electrical properties, extremely tough, unaffected by all known chemicals, excepting molten alkali metals under normal conditions, zero water absorption, unaffected by weathering, good non-sticking characteristics.

For further information, clip and mail coupon below. †REG. U. S. PAT. OFF.

DU PONT "FAIRPRENE"

synthetic elastic compositions

"ENGINEERED TO DO YOUR JOB BETTER"

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

*"**FAIRPRENE**" is Du Pont's registered trade mark for its line of products made from synthetic elastomers available in the form of coated fabrics, sheet stocks without fabric insert and adhesives.*

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division
Empire State Building, New York 1, N. Y.

- ☐ I am interested in Du Pont Technical Service.
- ☐ Please send me booklet "'FAIRPRENE' synthetic elastic compositions."
- ☐ Please send me Technical Bulletin "'TEFLON' Coated Glass Fabrics."

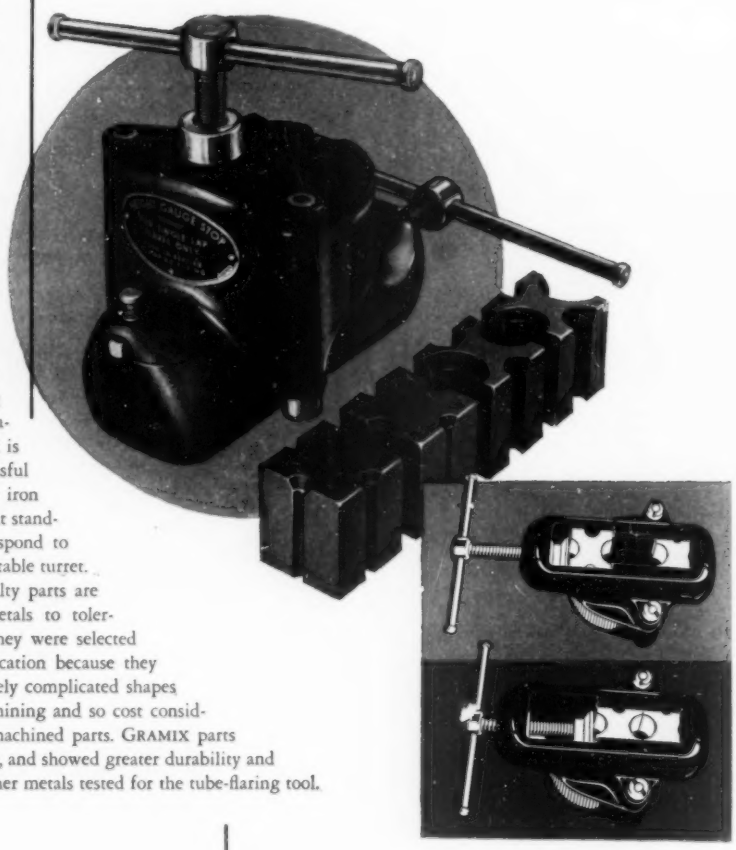
Name_____ Title_____

Firm_____

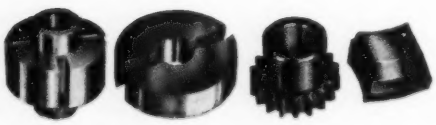
Address_____

precision formed GRAMIX® *die blocks*

prove their quality in this powerful little tube-flaring tool



The new Papco Roto-Master Tube-Flaring Tool made by the Penn Aircraft Products, Inc. of Dayton, Ohio has greatly simplified single or double lap flaring on all grades of tubing for oil and hydraulic line installations in aircraft. And GRAMIX is mighty important to the successful operation of this tool. Four iron GRAMIX die blocks provide eight standard tube diameters that correspond to the eight stations of the adjustable turret. GRAMIX bearings and specialty parts are die-pressed from powdered metals to tolerances as close as .0005". They were selected by Papco for this application because they can be produced in relatively complicated shapes that require little or no machining and so cost considerably less than machined parts. GRAMIX parts are strong and tough too, and showed greater durability and longer life than other metals tested for the tube-flaring tool.



GRAMIX parts are self-lubricating. Whatever your operation may be, we think you'll find that GRAMIX bearings and specialty parts will help cut costs and improve the performance of your product. For complete information, write today to . . .

87

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

LAMINATES News

News of General Electric Laminated Plastics that can be of importance to your business.

G.E.'S ULTRAMODERN OHIO PLANT SCENE OF LATEST LAMINATING TECHNIQUES

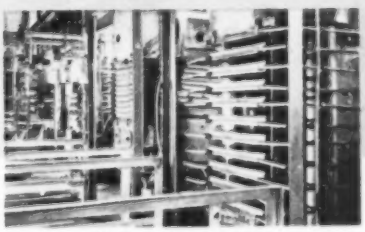
The General Electric Laminated Plastics Plant at Coshocton, Ohio—The latest techniques for producing laminated plastics are employed at this ultramodern, ¼-million-square-foot G-E plant.

Strict quality control, continuous research and modern manufacturing methods—at one of the country's newest and largest laminating plants—combine to give you top value in G-E Laminated Plastics.

You can depend on the complete General Electric service, including assistance in engineering, design and product development to supply you with laminates having exactly the right electrical, chemical and physical properties. *For full information, write Section Y-5, Chemical Division, General Electric Company, Pittsfield, Mass.* (Also send ten cents for the new G-E Laminates Comparator—a quick, easy reference to grades, characteristics and uses of laminated materials.)

Extensive laboratories for research and product testing.

Air conditioning protects quality of industrial grade treated materials in this storage bay.



Presses . . . Presses . . . Presses
Medium Size . . . Big Size . . . Giant Size

THE COMPLETE LINE OF G-E LAMINATED PLASTICS FOR INDUSTRY AND DEFENSE:
Sheets, tubes, rods, and molded forms, with cloth, paper, glass fabric or special bases for a wide variety of applications.

ALSO—look to General Electric for silicone insulation, insulating varnishes, sealing and filling compounds, mica insulation, varnished cloths and tapes.

You can put your confidence in

GENERAL ELECTRIC

Parts for Aircraft Engine Containers made from Cold-Formed Shapes

The two cold-formed shapes shown above are used as supports for containers which protect aircraft engines from dirt and moisture during shipment and storage. The circular shape is used in containers for radial-type engines, and the rectangular shape is used in containers for jet engines. We make each shape on a rolling machine, using ¼-in. steel, and supply them to the Rheem Mfg. Co. bent to shape, accurately punched, and welded.

Hardly a day passes but that someone comes up with a new use for Bethlehem Cold-Formed Shapes. In addition to supports for aircraft engine containers, waterways for radiant baseboards, side-plate sections for refrigerator cars, hatch covers for sea-going vessels, channels for telephone equipment, are just a few among a large number of recent new uses.

Bethlehem Cold-Formed Shapes are regular or irregular shapes formed cold from strip, sheet, bar or plate steel. They are uniform in thickness, and their surface is relatively free from scale.

They have an excellent strength-to-weight ratio. Our shop is equipped to turn them out on presses, brakes or rolls in gages from 5 to 24, inclusive.

Ask the nearest Bethlehem sales office to send you a copy of a new two-color booklet about Bethlehem Cold-Formed Shapes.

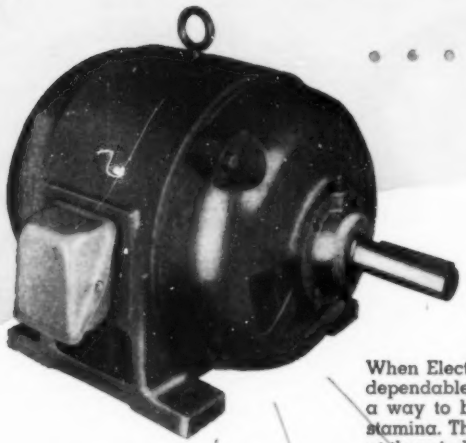
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

★ BETHLEHEM STEEL ★

ELECTRO DYNAMIC MOTORS

are tough where toughness counts!



Extra Heavy-Duty *Windings*
Reduce Costly Motor Failures

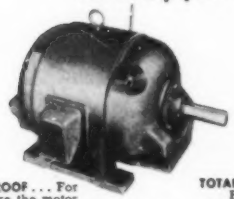
When Electro Dynamic was called on to manufacture super-dependable motors for submarines, our engineers developed a way to build electric motors with unusual toughness and stamina. Their method was to make the motors extra durable at the *windings*—"the heart of the motor".

That's why, today, special care and superior materials go into all E. D. windings. Furthermore, corrosion-resistant frames are of heavy cast construction. Every motor is dynamically balanced. As a result, you are assured of longer service, trouble-free operation and lower maintenance costs when you install E. D. industrial motors.

Find out how famous E. D. quality can improve your product and benefit your business. Write today for illustrated literature.

ELECTRO DYNAMIC INDUSTRIAL MOTORS are built in a wide range of types and sizes . . . 1 to 250 h.p. Shown above is an E.D. Drip Proof Industrial Motor. For use under ordinary industrial conditions not requiring protection from splashing liquids or from atmosphere laden with dirt or metal chips.

There's an E.D. MOTOR for every job!



SPLASH PROOF . . . For installation where the motor is subjected to splashing liquid or hosing down for cleaning.

TOTALLY ENCLOSED (Fan Cooled)... For dirt-laden atmosphere, especially where the installation requires a motor of compact dimensions.

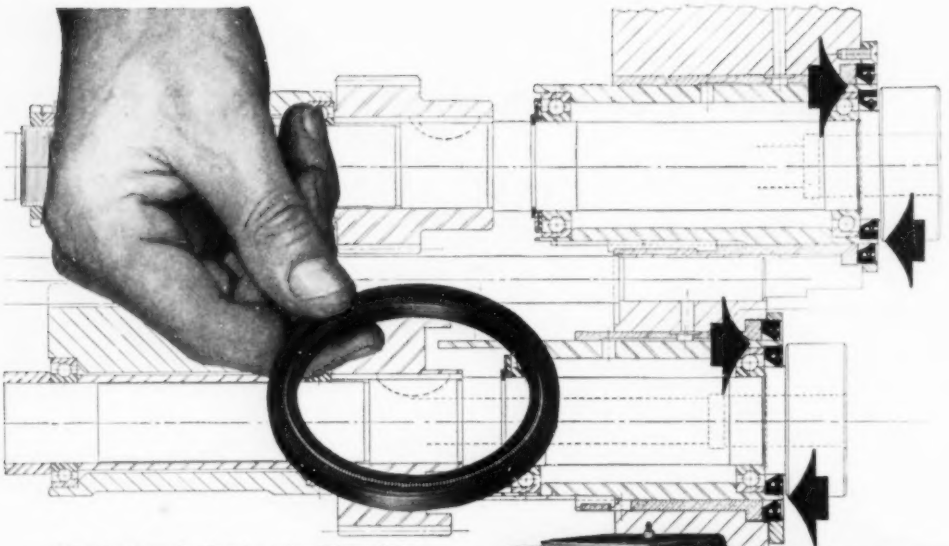
TOTALLY ENCLOSED (Non-Ventilated)... For use in exceptionally dirty atmospheres, particularly when metallic dust is present.

Industry has learned what marine engineers have known since 1880

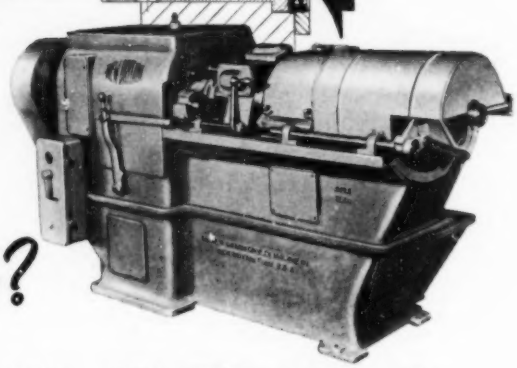
ELECTRO DYNAMIC builds great motors

E.D. Also Makes a Complete Line of DIRECT CURRENT Motors and Generators. Literature on Request.

ELECTRO DYNAMIC • Division of the Electric Boat Company • Bayonne, N. J.



Blueprint shows four locations where Clipper Seals help maintain smooth running, accurate operation of the New Britain Model 23A Chucking Machine. Photograph is of the complete machine.



Is this your OIL SEAL problem?

New Britain solved it with Clipper Seals

WHEN the New Britain Machine Company, New Britain, Conn., designed their model 23A Automatic Chucking Machine, they were planning a machine tool that would maintain its precision under long, hard service conditions.

This called for tough, precision-made components—of which Clipper Seals are an outstanding example. The compact design of these seals and their ability to do a highly efficient job of retaining lubricants, and sealing against cutting oils and abrasives, were important factors in New Britain's choice of Clipper Seals.

Clipper Seals won out on other counts, too. It was found that they decidedly reduce friction and wear, assuring trouble-free operation and long service life at high shaft speeds. In addition, Clipper Seals supplied the answer to easy installation because the tough, dense heel provides just the right amount of rigidity for a press fit in the cavity . . . while the flexible lip, held in light but positive contact with the shaft by an especially designed garter spring, provides effective sealing at all times.

These precision-moulded oil seals—made in both split and endless types—are available in a wide variety of designs, and in heel and lip compositions to meet practically any sealing requirement. For details, write for Brochure PK-46A. Address Johns-Manville, Box 290, New York 16, N. Y.

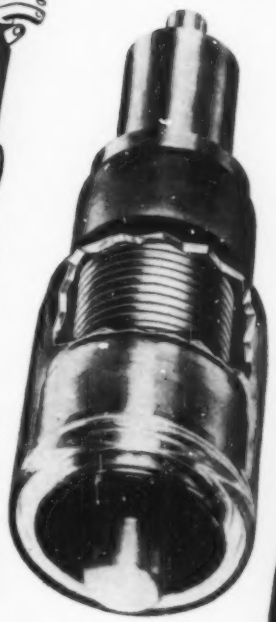
JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CLIPPER SEALS

ONLY A

Flexible, Leakproof Bellows COULD SOLVE

the case of the vacuum variable capacitor



When Jennings Radio Manufacturing Company first considered making vacuum variable capacitors, one of the big difficulties was finding a suitable seal. Ordinary sealing methods would not permit moving the adjustable plate while maintaining the vacuum.

What Jennings needed was a seal that would be both LEAK-PROOF and FLEXIBLE.

The solution was Clifford Hydron Bellows. Their leakproof quality forms a perfect seal for the vacuum yet their flexibility permits full movement of the variable plate! What's more, they remain vacuum tight after going through silver solder brazing in two areas . . . and they easily withstand the 480°C bake-out after brazing.

The use of these bellows has helped make possible the first practical vacuum variable capacitor. Jennings now offers capacitors for high power, high voltage work that permit quick, precise frequency shifting of even the largest transmitters.

Clifford Bellows have many applications in any of these categories: (1) actuating switches or valves for accurate control of temperatures or pressures; (2) sealing rotary shafts or packless valves against liquid or gas leakage; (3) providing a flexible joint for instruments combining rotary motion and hermetic seal; (4) transmitting motion hydraulically to remote points.

See how you can put LEAK-PROOF, FLEXIBLE, metallic bellows to work for you . . . send coupon below today.

P.S. Clifford engineers will gladly make a confidential analysis of your sketches and specifications without cost or obligation.

CLIFFORD

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

CLIFFORD MANUFACTURING COMPANY, 122 Grove Street, Waltham 54, Massachusetts
Division of Standard-Thomson Corporation
Sales offices in New York 17, Detroit, Chicago 1, Los Angeles

FREE! **Please send me my copy of the bulletin "What to Consider When Selecting a Metallic Bellows". I am interested in the applications checked.**

- ☐ Air conditioning systems
- ☐ Aircraft
- ☐ Carburetor altimeter controls
- ☐ Engine thermostats
- ☐ Gasoline valves
- ☐ High pressure steam devices
- ☐ Heating equipment
- ☐ Instruments
- ☐ Remote or direct control oil temperature and pressure
- ☐ Compensating regulators
- ☐ Electric or gas ranges
- ☐ Kilns & ovens — industrial
- ☐ Air compressors
- ☐ Oxygen flow indicators
- ☐ Oxygen regulators
- ☐ Process controls
- ☐ Refrigerating systems — commercial
- ☐ Shaft seal assemblies
- ☐ Fuel pumps
- ☐ Fluid couplings
- ☐ Supercharger controls
- ☐ Refrigerator controls — domestic
- ☐ Torque converters

Other applications . . . . . .

Name . . . . . Title . . . . . .

Firm . . . . . .

Street . . . . . .

City . . . . . Zone . . . State . . . . . .

. . . turning wings into fuel tanks

With the increased operational range of the modern airplane, up to *three tank cars* of fuel may have to be carried. Such capacity involves a real problem in design. One answer is the "integral wing tank" where large sections of the wing become integral fuel tanks. Working closely with aircraft engineers, 3M developed a sealer that closes the cracks and crevices, tightly sealing the fuel space.

Consider the requirements such a sealer must meet. It must adhere perfectly to the metal under severe service conditions. It must resist rapid and extreme changes in both pressure and temperature. It cannot crack or lose adhesion with wing flex nor can gas or oil change its properties.

3M integral fuel tank sealers are only one specialized type of adhesive . . . and the development of many such compounds for all industry is a specialty of 3M.

See what adhesives can do for you . . .

WRITE FOR 3M'S 32-PAGE BOOKLET ON ADHESIVES, COATINGS AND SEALERS. IT'S FILLED WITH INTERESTING INFORMATION AND EXAMPLES OF SUCCESSFUL APPLICATIONS IN ALL INDUSTRIES. ADDRESS YOUR REQUEST TO 3M, DEPT. 49, 411 PIQUETTE AVE., DETROIT 2.

3M COMPANY

OVER 1,000 BASIC

ADHESIVES · COATINGS · SEALERS

ADHESIVES AND COATINGS DIVISION · MINNESOTA MINING AND MANUFACTURING COMPANY
411 PIQUETTE AVE., DETROIT 2, MICH.
GENERAL OFFICES: ST. PAUL 6, MINN.
EXPORT AND CANADIAN SALES: 270 PARK AVE., NEW YORK 17, N. Y.

FRANKLIN ...FIRST to draw Lightning from the Skies

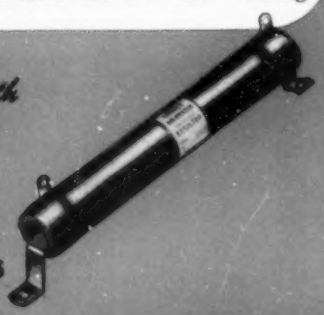
Benjamin Franklin
1706-1790

This illustrious American statesman, philosopher, writer, and scientist was the first to identify lightning with the electrical discharge from a Leyden jar. His famous kite-and-key experiment led to the invention of the lightning rod. He also established the law of the conservation of electrical charge, and determined the *positive* and *negative* nature of electricity.

From an original drawing made for OHMITE.

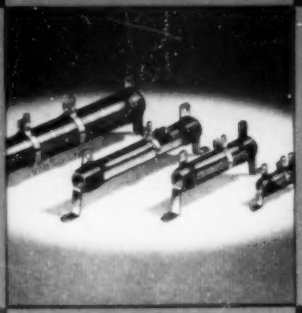
OHMITE® ...FIRST in Resistors ...today

Be Right with
OHMITE
RHEOSTATS
RESISTORS
TAP SWITCHES



Ohmite offers the most complete line of wirewound resistors on the market today. These Ohmite resistors have become world renowned for their dependability . . . their ability to give unfailing, long-life performance under adverse operating conditions. For extra dependability, specify Ohmite resistors—overwhelmingly the first choice of industry today.

OHMITE
WIRE-WOUND RESISTORS



"DIVIDOHM" ADJUSTABLE TYPE

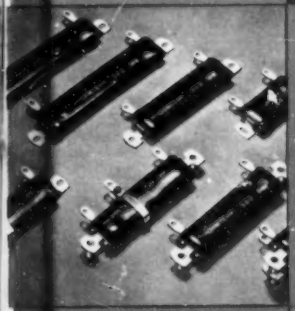
Vitreous-enameled type, with windings exposed along one side for contact with adjustable lugs. Used for final resistance adjustments; for securing odd values quickly; and as voltage dividers. In 10 to 200 watts; 1 to 100,000 ohms.

WIRE LEAD TYPE

These small vitreous-enameled resisters can be connected and supported by their own 1½" tinned copper terminal leads. All-welded construction makes possible higher resistance values. Size—5, 10, and 20 watts; resistance values—0.4 to 2,500 ohms.

LUG TYPE

This type is the most popular, having wide use in general applications. Vitreous-enameled coating. Connected by soldering or bolting leads to the lugs. Available in five standard core sizes — 25 to 200 watts; resistance values from 1 to 250,000 ohms. Special sizes and terminal arrangements also available.



THIN TYPE

Compact design gives these vitreous-enameled units a higher wattage rating per unit of space. Integral mounting brackets cannot rotate or loosen. Special studs allow stacking. Units are only ¼" thick, 1" wide, and 2" to 6½" long. Five sizes, from 35 to 75 watts; resistances—0.1 to 100,000 ohms.

"CORRIB" TYPE

Vitreous-enameled coating holds edge-wound, corrugated ribbon winding securely in place. For low resistance applications where high wattages must be dissipated. Many resistances available in a wide range of core sizes from 90 to 1,500 watts.

PRECISION TYPE

These ½- and 1-watt units, of 1% or closer tolerance, are used in test equipment, amplifiers, etc. Standard vitreous-enameled units, or pie-wound, non-inductive windings, in vacuum-impregnated or glass-sealed types. From 0.1 to 2,000,000 ohms.

NON-INDUCTIVE TYPE

For practically constant resistance and impedance in R.F. circuits, such as radio transmitters, diathermy apparatus, R.F. test equipment, dummy radio antennae. Vitreous enameled. Available in sizes from 50 to 160 watts, and in resistances from 5 to 5,000 ohms.

Select the TYPE YOU NEED
FROM THE MOST COMPLETE
LINE ON THE MARKET—

OHMITE®

WRITE ON COMPANY
LETTERHEAD FOR CATALOG
AND ENGINEERING
MANUAL NO. 40

OHMITE MANUFACTURING COMPANY
4819 Flournoy St., Chicago 44, Illinois

Specify The V-Belt Sheave

which all industry likes best

QD

TRADE MARK Pat. No. 2269821

Split hub is clamped to shaft. Heavier taper-bored rim slides easily over tapered hub—no keyway obstruction on cone surface. Positive press fit on shaft. Large, long pull-up bolts also used as jack screws to remove rim.

Here's a 26-word description of the V-belt sheave that is used more than any other.*

Two parts for easy handling—separately or together. Split hub and taper-mated rim make mounting easy. No realignment problem—clamped hub stays put while changing rims.

That's Worthington's QD—the original tapered cone-grip sheave that's preferred by men who have to install or change sheaves. The QD is *easy to get on, easy to get off, yet always tight on the shaft*—tighter than any other sheave on the market. Hubs for every bore—lower inventory cost.

For your machines, pick Worthington Multi-V-Drives with QD sheaves and Worthington-Goodyear EC Cord V-belts.

Worthington's complete line also includes FHP drives—QD Junior (quick-detachable) V-pulleys and many other styles.

Send coupon for Bulletin V-1400-B7F, addressing our Harrison office.

**In addition to being one of the largest-selling sheaves, the popular Worthington QD design is licensed to many other sheave manufacturers. For your customer's protection, dimensions are standardized to permit interchangeability*

M.V.1.8

WORTHINGTON

THE GOOD RIGHT HAND OF INDUSTRY

POWER TRANSMISSION: sheaves, V-belts, variable speed drives

PUMPS: centrifugal, power, rotary, steam

AIR COMPRESSORS: water-cooled, air-cooled

Worthington Pump and Machinery Corporation
Multi-V-Drive Sales Division
Buffalo, New York

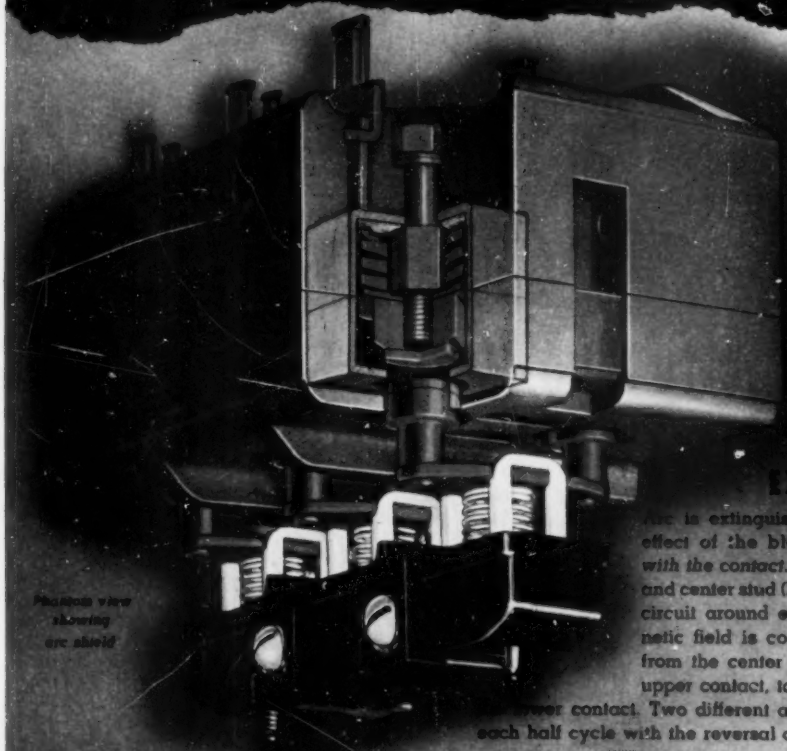
Send Bulletin V-1400-B7F on Worthington Multi-V-Drives.

Name .....

Company .....

Address ..... Zone .... State ...

The All New CLARK TYPE "CY" AC MOTOR



Phantom view showing arc shield

...here's how the ARC is EXTINGUISHED

...arc is extinguished by applying the effect of the blow-out coil concentric with the contact. The steel arc chamber and center stud (blue) form the magnetic circuit around each contact. The magnetic field is concentrated in a cone from the center stud that supports the upper contact, to steel rim surrounding ...lower contact. Two different actions occur, changing each half cycle with the reversal of the current.

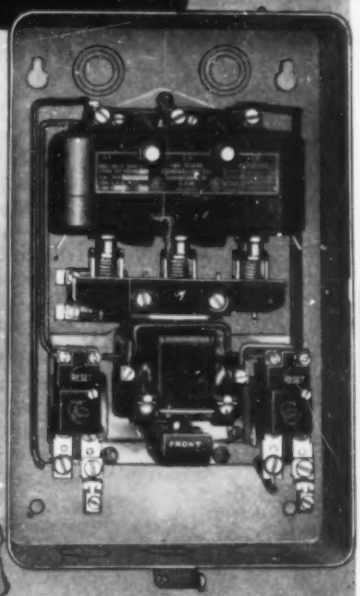
...current direction the arc is forced to the outer edge of the upper contact, lengthened and rotated. In the other, the arc is rotated and forced to the middle of the upper contact. In each case, the magnetic field tends to quench the arc, either by lengthening it or confining it.

Constant forced rotation of the arc, moving continually from a hot to a cold spot, minimizes burning and pitting of contacts.

Let a CLARK application engineer show you what this BLUE RIBBON PRODUCT means to you in increased production and lower maintenance.

CLARK ENGINEERED ELECTRICAL CONTROL

— STARTER features an entirely new principle in ARC INTERRUPTION



Another CLARK First! In the Type "CY," CLARK offers, for the first time, a line of AC Motor starters that gives you the extra protection of "Mill-Type" heavy-duty construction and design. These new starters feature the combined use of strong multi-turn magnetic blow-outs and twin-break contacts* to achieve a new high in arc-interrupting efficiency.

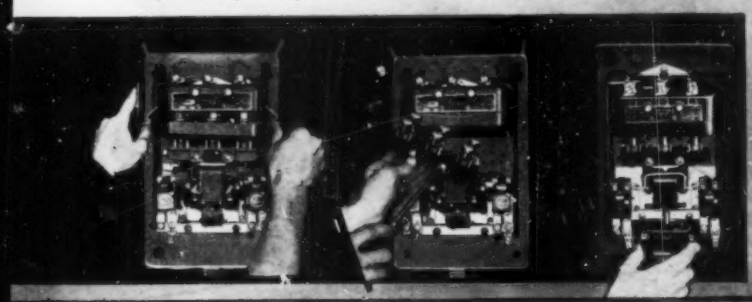
Other important advantages include:

- One piece upper arc shield, closed at the top, to prevent accumulation of hot gases between wiring terminals, minimizing phase-to-phase failures.
- Magnetic arc interrupters in steel arc chambers.
- Silver alloy double break contacts.
- Melting-alloy type overload relays.
- Vertical-lift clapper type magnet with straight line guided movement, using no springs.

*Magnetic blow-out coils are used on all Size 2 and 3 "CY" Starters. Sizes 0 and 1 use the same general Mill-Type construction as larger sizes.

The Maintenance Man's Dream

The new arc interrupting principle and twin-break silver-alloy contacts, assure longer contact life. No filing, dressing or cleaning of contacts is required. Inspection and maintenance are further simplified by design features.



- No tools needed to inspect contacts.
- Moving contacts easy to change.
- Stationary contacts quickly changed.
- Remove only two screws and one pin to change coils.
- All parts removable from the front.

THE CLARK CONTROLLER CO.

1146 EAST 152ND STREET · CLEVELAND 10, OHIO

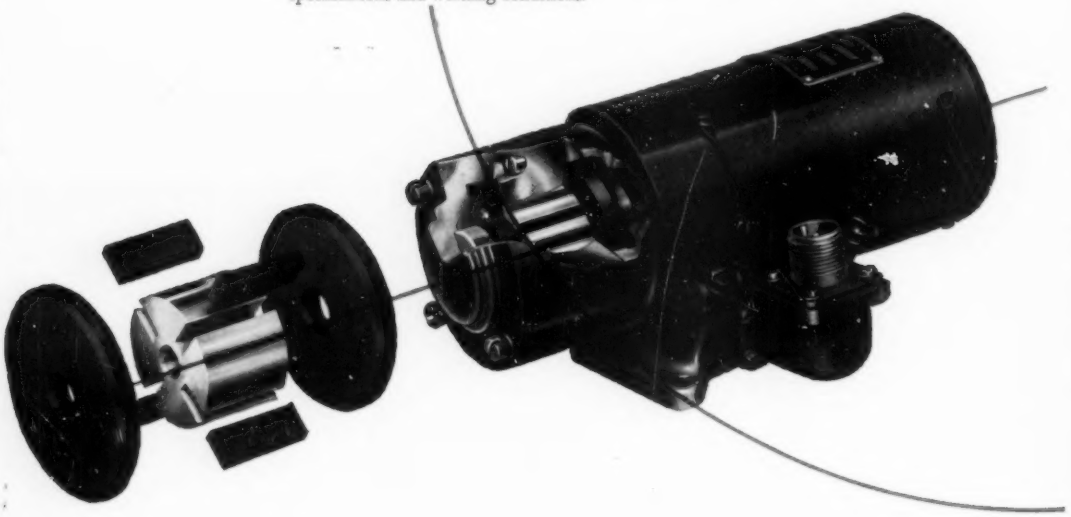
GRAMIX® and GRAPHITAR®

help Lear-Romec air pumps

operate efficiently at 10 miles up!

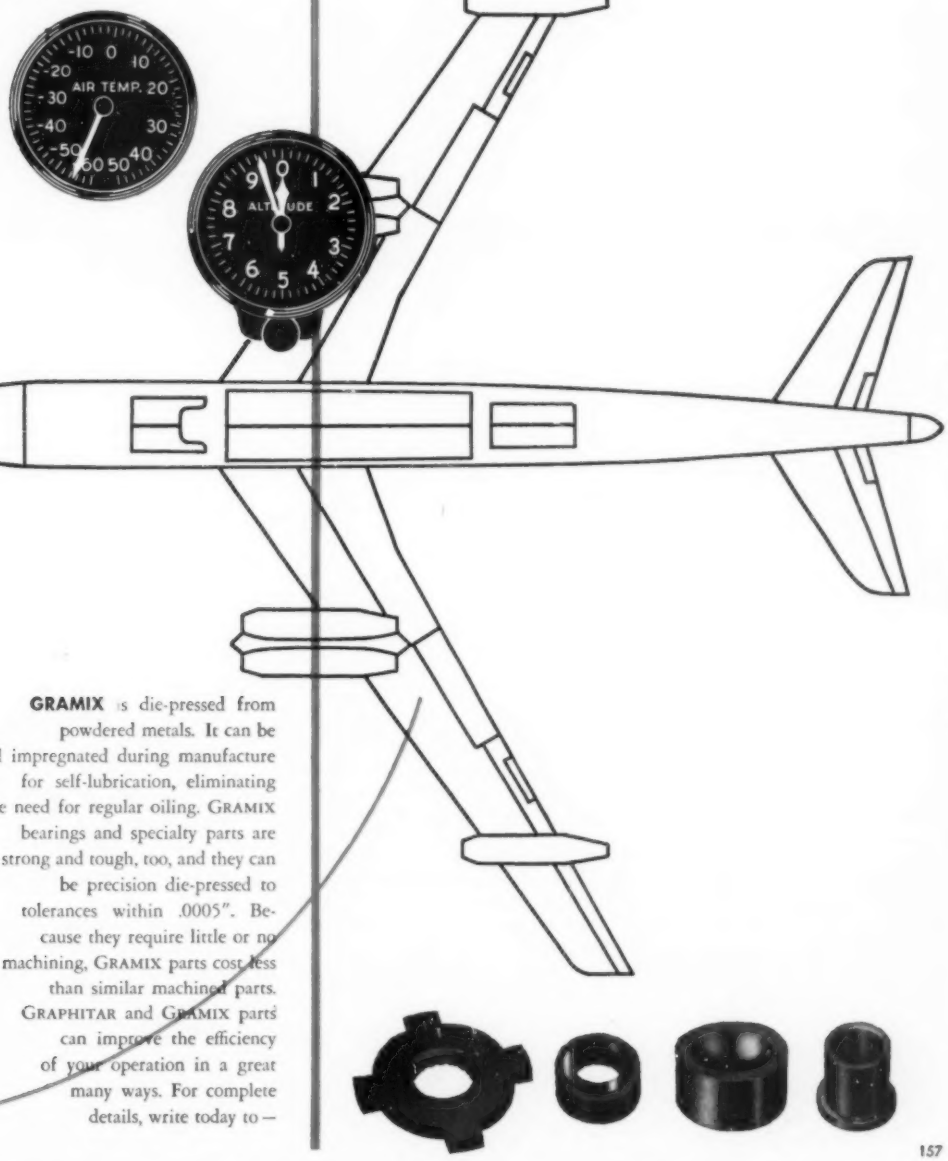
When a pilot is ten miles high with the temperature down around fifty below, it's mighty important to have radar equipment that he can depend on. It's the job of this little 1/15 hp air compressor made by Romec Division of Lear, Inc., in Elyria, Ohio, to keep radar functioning efficiently. And one of the big reasons the compressor does its job so well is because it's made with GRAPHITAR vanes and end plates and a GRAMIX rotor. At temperatures as low as 67° below zero Fahrenheit and altitudes of 50,000 feet, this little pump delivers a constant supply of oil-free compressed air at "sea-level" pressure for radar and electronic equipment. It will operate continuously at 4600 rpm for 1000 hours. The GRAPHITAR and GRAMIX parts are vital to this efficient performance.

GRAPHITAR is a versatile engineering material for seals, bearings, cylinder liners, pistons and countless other parts. It can be formed into relatively complicated shapes and ground to tolerances as close as .0005". GRAPHITAR is extremely light weight yet mechanically strong and highly resistant to wear, making it ideal for use where weight is a factor. GRAPHITAR will improve your product performance and save critical metals such as steel or aluminum for defense production. It is available in many different grades to meet particular specifications and working conditions.



THE UNITED STATES

PARTS

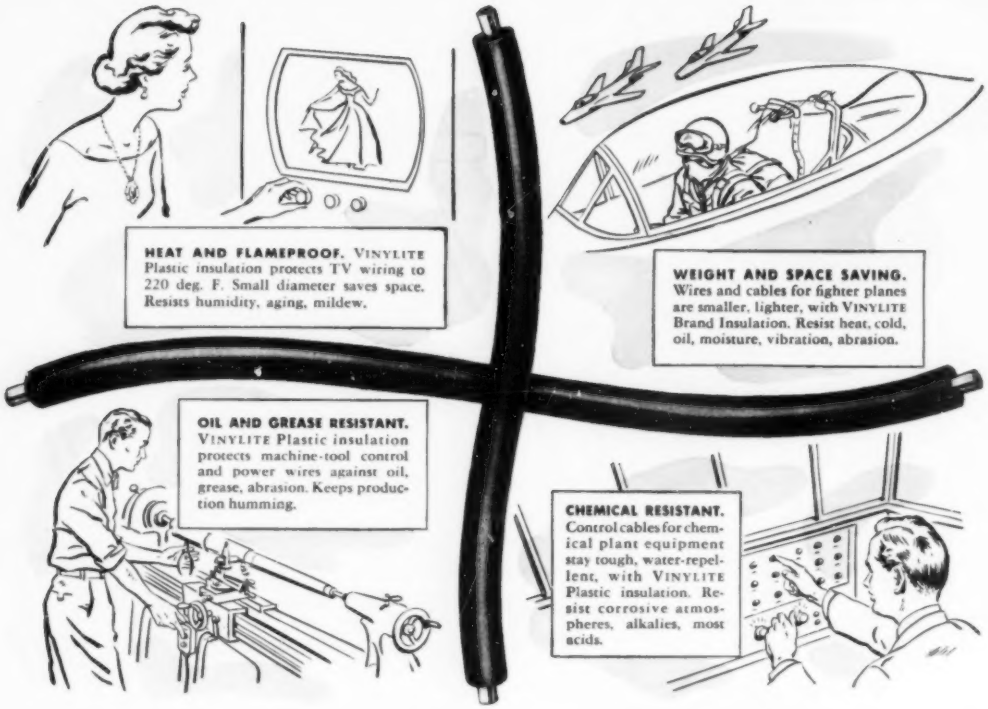


GRAMIX is die-pressed from powdered metals. It can be oil impregnated during manufacture for self-lubrication, eliminating the need for regular oiling. GRAMIX bearings and specialty parts are strong and tough, too, and they can be precision die-pressed to tolerances within .0005". Because they require little or no machining, GRAMIX parts cost less than similar machined parts. GRAPHITAR and GRAMIX parts can improve the efficiency of your operation in a great many ways. For complete details, write today to—

157

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN


HEAT AND FLAMEPROOF. VINYLITE Plastic insulation protects TV wiring to 220 deg. F. Small diameter saves space. Resists humidity, aging, mildew.
WEIGHT AND SPACE SAVING. Wires and cables for fighter planes are smaller, lighter, with VINYLITE Brand Insulation. Resist heat, cold, oil, moisture, vibration, abrasion.
OIL AND GREASE RESISTANT. VINYLITE Plastic insulation protects machine-tool control and power wires against oil, grease, abrasion. Keeps production humming.
CHEMICAL RESISTANT. Control cables for chemical plant equipment stay tough, water-repellent, with VINYLITE Plastic insulation. Resist corrosive atmospheres, alkalies, most acids.

Wired for ENDURANCE!

VINYLITE BRAND PLASTIC INSULATION KEEPS THEM WORKING!

In chemical plants, refineries, machinery and electronic equipment, wires insulated with VINYLITE Brand Plastics have proved themselves time and again. Such wires are specified because they *last*—they have been seven years under water, twelve years under ground without a failure.

They can be made to stay flexible and tough down to —60 deg. F., or to keep their insulating properties up to 220 deg. F. Their resistance to water, oils, greases, alkalies, most strong acids, sunlight, age, mildew is unsurpassed.

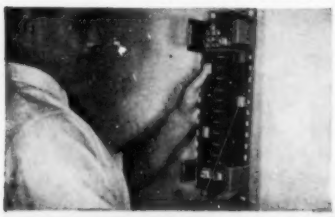
They permit smaller diameters, taking up less space. Their smooth surfaces pull easily around corners. They strip and splice with ease, and their unlimited range of lasting colors makes color-keying positive and permanent.

Wire manufacturers seeking specific data on high-quality jacketing compounds with outstanding low-temperature properties—or on other VINYLITE Plastic compounds for wire and cable—are urged to write Dept. LA-10.

Vinylite
BRAND
PLASTICS

TRADE MARK

BAKELITE COMPANY
A Division of
Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.



UNMATCHED PERFORMANCE. New panelboard bus bars are *molded right in* plastisols of VINYLITE Resin. They provide resistance to acids, alkalies, shrinkage, embrittlement, tracking, carbonizing, heat. Plastisol by Stanley Chemical Co., East Berlin, Conn. for Trumbull Electric Mfg. Co., Plainville, Conn.

LIFE-LONG PROTECTION is now provided economically for identification photos and tags laminated between VINYLITE Rigid Sheets. These stable, transparent materials won't curl or fray. They're moisture-, perspiration-, chemical-resistant, too. By Malco Plastics, 2214 Sulgrave Ave., Baltimore 9, Md.

GRAND SLAMMER. VINYLITE Rigid Plastic breaker strips for new Philco refrigerators withstand door slams for years on end! Provide utmost resistance to food acids and alkalies, greases, oils, fats, moisture, cleaning, abrasion, and thermal shock. Smooth, gleaming surface wipes clean with a damp cloth.

is light weight important to your product?

Torrington Needle Bearings contribute to weight-and-space-saving design in many products.

For any given load, Needle Bearings weigh less and require less radial space than any other type of anti-friction unit.

Needle Bearings also permit weight savings in related components. Only a bore machined to proper dimensions is required for the housing and no spacers or retainers are needed.

So, if your product can benefit from light weight, let our engineers help you utilize the weight- and space-saving advantages of Torrington Needle Bearings.

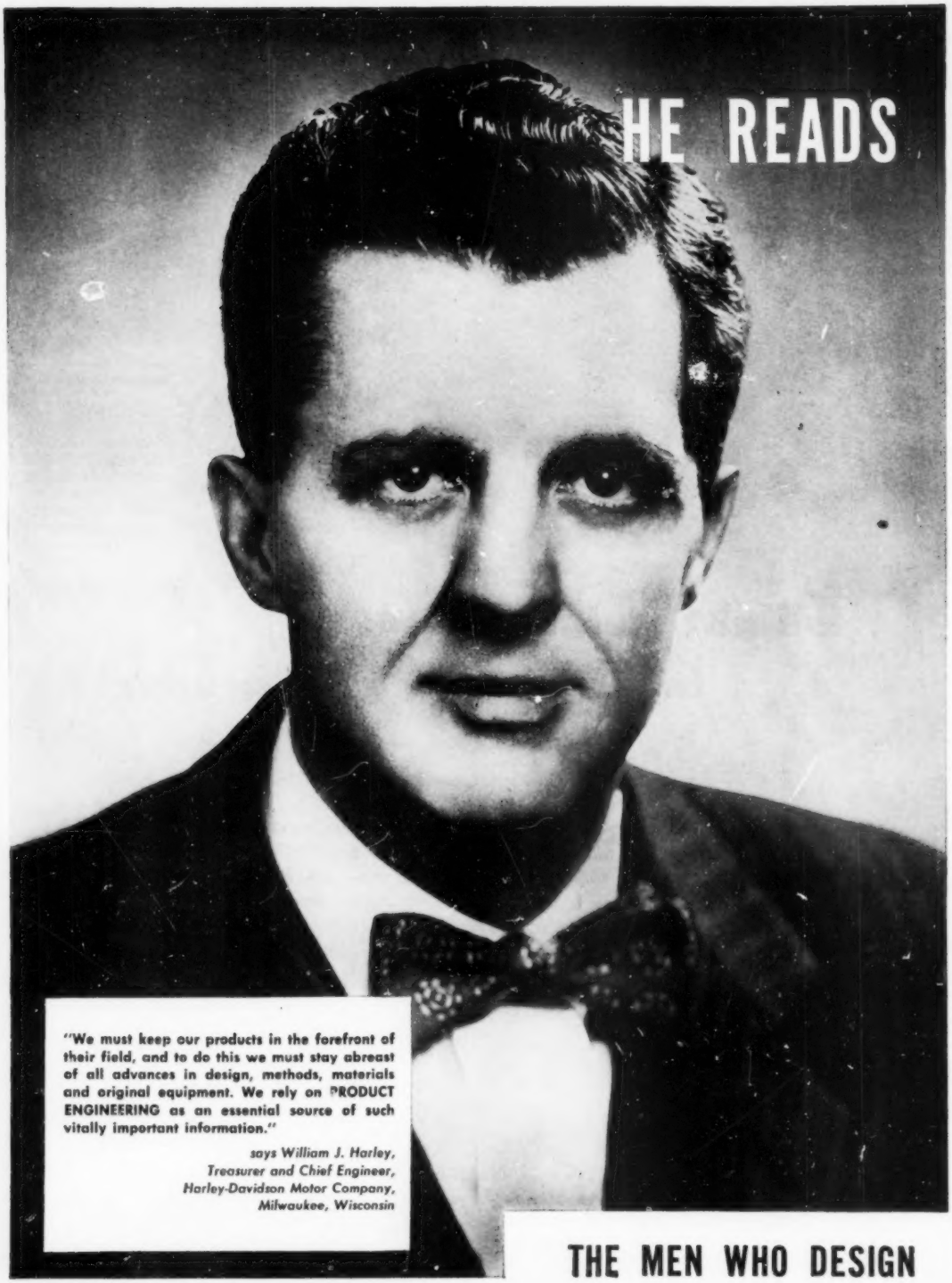
THE TORRINGTON COMPANY

Torrington, Conn. • South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON *NEEDLE* BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS



"We must keep our products in the forefront of their field, and to do this we must stay abreast of all advances in design, methods, materials and original equipment. We rely on PRODUCT ENGINEERING as an essential source of such vitally important information."

says William J. Harley,
Treasurer and Chief Engineer,
Harley-Davidson Motor Company,
Milwaukee, Wisconsin

THE MEN WHO DESIGN

HE DESIGNS MOTORCYCLES...

PRODUCT ENGINEERING

When you sell to transportation-equipment manufacturers . . . or any industry which can use your products as Original Equipment . . . there's no substitute for PRODUCT ENGINEERING'S sales power

EVEN casual examination of a modern motorcycle will convince you that its design requires engineering skill of a high order . . . and the selection and specification of an astonishing variety of materials, parts, components and finishes.

And when you want *your products* specified as Original Equipment* on today's motorcycles . . . or *any other* machinery, equipment, or appliances American industry manufactures . . . *concentrate your advertising* in PRODUCT ENGINEERING . . . the magazine product-design engineers prefer to all others edited for them . . . the *only* design magazine these basic buyers in the Original Equipment Market *pay to read*.

Everywhere in America's biggest market for parts, materials, components, and finishes . . a $26 billion market in 1951 . . . PRODUCT ENGINEERING gives you top coverage, penetration, and SALES IMPACT . . . at lowest cost.

Get the facts on the more than 18,000 technical design men in management who subscribe to and pay for PRODUCT ENGINEERING. Men who buy PRODUCT ENGINEERING because it gives them the kind of information they want . . . edited for them by the highest-paid and best-qualified editorial staff of its kind — anywhere.

Ask your nearest PRODUCT ENGINEERING representative for *all* the facts about this top sales force in your biggest market. He can show you quickly why PRODUCT ENGINEERING will sell your products to industry's basic buyers of Original Equipment with more impact, and at less cost, than any other design magazine.

PRODUCT ENGINEERING

ABC ABP

A McGraw Hill Publication
McGraw-Hill Building, New York 18

DISTRICT OFFICES: Atlanta 3 • Boston 16 • Chicago 11 • Cincinnati 8 • Cleveland 15 • Dallas 1 • Detroit 26 • Los Angeles 17 New York 18 • Philadelphia 3 • Pittsburgh 22 • San Francisco 4

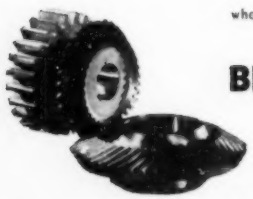
PRODUCT ENGINEERING CARRIES MORE ORIGINAL EQUIPMENT* ADVERTISING THAN ANY OTHER MAGAZINE IN THE WORLD!

*Every company which manufactures machines, equipment or appliances is a part of your giant Original Equipment Market. To reach and sell this big, repeat-order market, over 600 display advertisers now invest, in PRODUCT ENGINEERING'S proved readership, far more advertising dollars than are invested in the readers of any other design magazine. These advertisers know that from the men who read PRODUCT ENGINEERING flows the authority to specify, approve, and buy their products . . . in the big quantities and repetitive orders which boost volume and cut sales costs down.

AMERICA'S NEW PRODUCTS READ PRODUCT ENGINEERING

CONTROL in the manufacture of gears, is, we think, a matter of complete control . . . control of every operation.

- At BRAD FOOTE we have complete control of each step from the inception of the original design to the delivery of the finished gears you use. For here . . . in our own plant . . . we design, engineer, machine, heat-treat, test, inspect, clean, and finish every gear. No one shares our responsibility.
- Our control guarantees the quality of BRAD FOOTE gears . . . gives you assurance that the gears you buy will perform satisfactorily when used in your shop . . . or on the equipment you sell to others.



BRAD FOOTE GEAR WORKS, Inc.

Bishop 2-1070 • OLympic 2-7700 • 1309 South Cicero Avenue
Cicero 50, Illinois

Materials ~ AVAILABILITY AND TRENDS

THE STOCKPILE

Despite an over-all narrowing of the gap between goals and supplies on hand, the stockpile is actually losing ground in some of the scarcest materials. The July stockpile report to congress showed it to be $700,000,000 closer to the objective than it was six months ago. But these figures don't show that some critically short materials have been diverted from the stockpile to industry, to relieve production bottlenecks. Nor do they show that the rate of delivery to the stockpile has been cut down in other cases, for the same purpose.

Details are secret, of course. But it's a good guess that copper is one of the materials that has been allowed to lag. Nickel might well be another. There are indications that chromite is lagging, despite big imports. It is known that the stockpile's take of tin was cut a third in June--and not because any goals had been reached. Cobalt, tungsten and molybdenum have been under terrific pressure, and may have lost some ground in the stockpile program.

Right now, of course, all this means things are a bit easier than they would be if the stockpile programs were being rigidly adhered to. But it also means a postponement of the day when the stockpile will withdraw from the materials market. It means a somewhat milder scarcity, spread over a long period of time.

POLITICS AND TIN SUPPLY

The official NPA goal is to hold the use of pig tin down to 60,000 tons this year. But RFC officials figure consumption will be 70,000 tons or more. The difference in these estimates is a tip-off to a somewhat easier tin situation.

Not that we have any more tin. It's simply a top-level policy to allow consumption to expand a bit, in order to back up RFC claims that it now can control the world tin price. That claim rests on supposedly ample supplies in this country. As a reflection of this easing-up policy there probably will not be any changes in NPA rules concerning tin. More likely, it will show up in administrative decisions regarding appeals, complaints and directives.

CHROMIUM PLENTIFUL

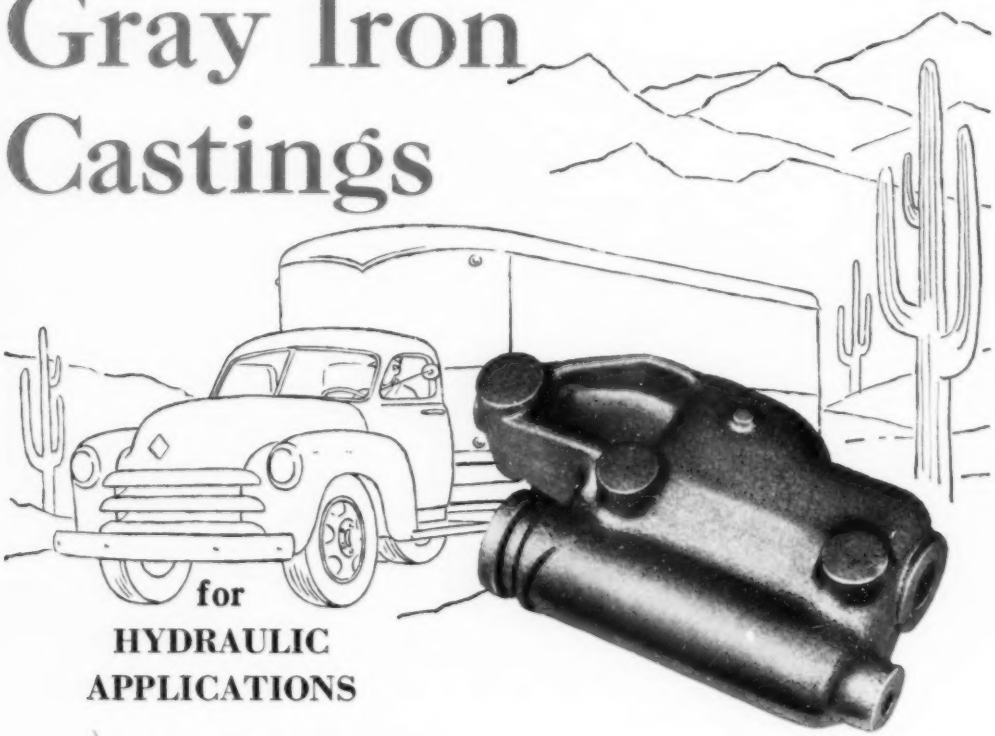
Chromite imports are holding up well, and chromium continues to be the most plentiful of the important alloy materials. It is relatively free of controls, as shown by plans to sheath four buildings in Pittsburgh with a 70 percent chrome steel. These plans don't violate any NPA rules so long as chromium alone is involved. Chrome-nickel steels would, of course, be barred for such a purpose. Chances are that chromium will be in fairly ample supply even if plans go through to allocate more chromite to the stockpile.

CADMIUM OVER-CONTROLLED

NPA eased the restrictions against the use of cadmium because supplies were backing up in unused inventories. NPA's amendment to the cadmium conservation order, M-19, restores its use in bearings for automotive replacement parts. The amendment raises from 19 percent to 25 percent the permitted use of cadmium in silver-brazing alloys. What happened was that NPA over-controlled cadmium, thinking that defense contracts were going to require more of it than has been the case.

(continued on page 115)

Eaton Permanent Mold Gray Iron Castings



for HYDRAULIC APPLICATIONS

- **Free machinability**
- **Dense, homogeneous structure**
- **Freedom from leakage under pressure**
- **Machines to high, mirror-like finish**
- **Properly annealed; no growth or distortion after machining**

Send for your copy of the illustrated booklet, "A Quick Picture of the Eaton Permanent Mold Process for Producing Gray Iron Castings."

EATON MANUFACTURING COMPANY

CLEVELAND, OHIO

FOUNDRY DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

TUNGSTEN REMAINS TIGHT

NPA is talking about an increase in tungsten supply. It cites expansion of domestic production and the possibility of an increase in imports from Korea. Trouble is, the domestic increase is only a fraction of unfilled demand, and Korean output, even if restored, won't reach here in important amounts for months. Experts in the Defense Minerals Administration list tungsten as one of the long-range shortages, which won't be solved in the foreseeable future.

Vanadium is in a happier situation. Supply is holding up, and can be further increased, NPA says.

NICKEL, COBALT, STAINLESS STEEL

So many defense supporting industries are asking for increase allotments of nickel, that makers of household electrical appliances fear the pruning knife will be used on them again. They told NPA that they can't take any more cuts in the use of nickel without reducing the quality of their products.

A possible substitute for nickel in chromium trim is being studied by DuPont. A white brass (an 80/20 zinc-copper alloy) is electroplated from a cyanide bath, and then chromium plated. The result is a product which DuPont claims has the appearance of chromium plated on nickel.

Cobalt is scarcer than ever, due to growing demand for jet engines. The tool steel industry has been advised to end the use of cobalt in tool steels, except for cutting tools. A big increase in U.S. production is underway, but it can't affect the supply before late 1952. Cobalt is one of the metals which Defense Minerals Administration thinks will be short indefinitely. Only solution, as DMA sees it, is to design it out of as many products as possible.

Small users of stainless and other steel alloys who get their supplies from warehouses are assured a supply by a new NPA set-aside order to producers. Warehouses are granted a base period of Jan. 1 through Sept. 30, 1950. Producers are required to ship them 85 percent as much stainless steel, as in the base period, and 100 percent as much commercial alloys.

The military is reducing its demand for columbium-stabilized stainless steel sheets for aircraft engines by switching to titanium.

ALUMINUM EXPANSION

The aluminum expansion program is on the rocks while planners argue over big companies which can expand, and little companies that can't get financing. Many top policy makers are against any more expansion for the established producers--Alcoa, Kaiser and Reynolds. The Justice Department has joined them, on the grounds that any more expansion of the big three would raise the monopoly issue. But the best efforts of the expansion bosses have failed to bring an independent into the picture. They still have one hope--Harvey Machine Co. One reason why President Truman established the New Defense Materials Procurement Agency was to get aluminum expansion started again. Aluminum is heading toward a peak demand by the military in the first quarter of 1952. After that, there may be a little easing.

COPPER PICTURE GLOOMY

The only bright spot in copper is the price increase allowed domestic refiners who buy copper-bearing raw materials abroad. The rise will keep copper coming into the country which otherwise would have been diverted to foreign consumers. The over-all supply picture remains gloomy. The peak military demand won't come until the second quarter of next year, which means copper will be one of the last of the major metals to get any relief. This will bring pressure to bear on the copper conservation program. Aluminum will be looked to as a substitute for copper in the electrical field.

Thomas A Edison

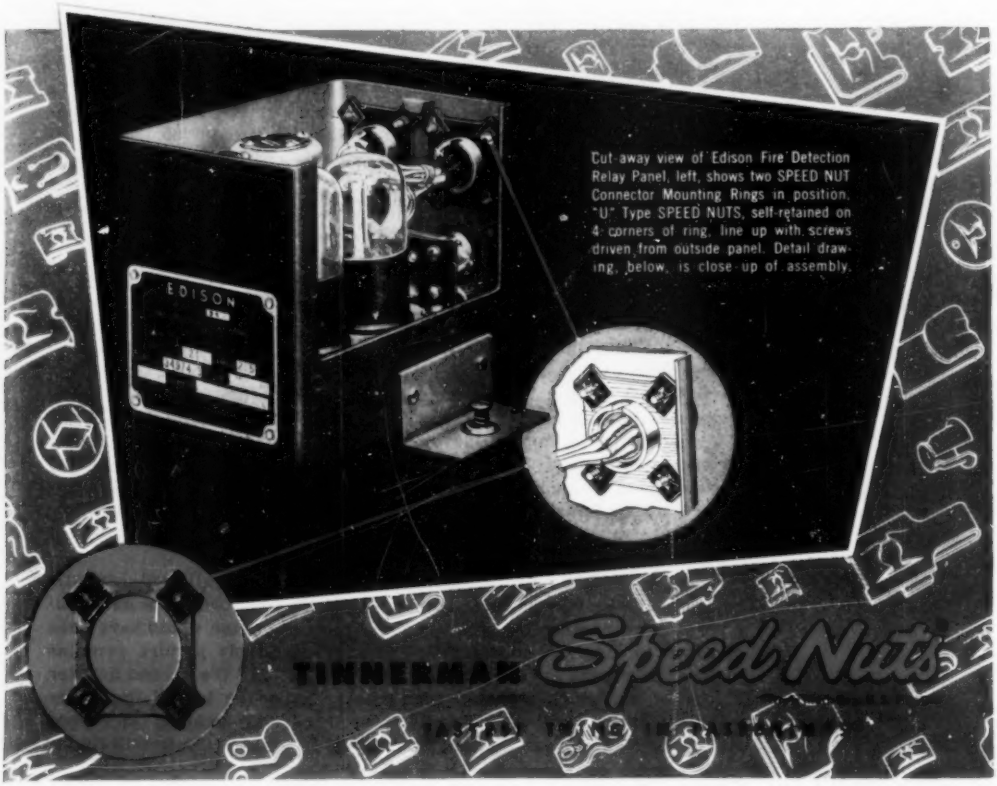
Cuts Costs in Half with SPEED NUTS®

Edison specifies SPEED NUTS after cost comparisons reveal 50% savings over other militarily acceptable fastening methods.

In the very earliest design stages of their aircraft fire detection relay panel, engineers of Thomas A. Edison, Incorporated, checked various methods of attaching connectors to the panel.

Their requirements were rigid. The fastening means had to be light in weight, resist vibration loosening, provide quick and easy assembly, and be in line on cost. Tinnerman Aircraft Connector Mounting Rings proved to be the only fastener that qualified on all counts. Connectors are quickly inserted through these mounting rings and the panel.

As for cost, Tinnerman SPEED NUTS *turned in the finest record by far! Easily 50% assembly savings over acceptable military substitute fasteners were provided by faster, easier, better* SPEED NUTS. Complex or simple, solving fastening problems is Tinnerman's specialty. New booklet, "A Story of Quality", reveals how we can help you. Write for your copy. TINNERMAN PRODUCTS, INC., Dept. 12, Box 6688, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners Ltd., Hamilton. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales.


EDISON
Cut-away view of Edison Fire Detection Relay Panel, left, shows two SPEED NUT Connector Mounting Rings in position. "U" Type SPEED NUTS, self-retained on 4 corners of ring, line up with screws driven from outside panel. Detail drawing, below, is close-up of assembly.
TINNERMAN
Speed Nuts

Desire, Ambition, and Aspiration

WORDS HAVE MANY GRADATIONS OF MEANING. Often the associated words in a sentence will make clear the exact meaning or intent of the writer or speaker. On the other hand, the speaker might have failed to analyze the exact thought which he was trying to convey. Environment, immediate events and the emotions of the speaker will often color his thoughts and thereby he may not mean what his spoken words say.

In a flourishing, highly animated speech a man emphatically set forth his "ambitions". The fact was he really had no ambitions. He had nothing more than strong desires. One might say he had "the gimmes".

Ambition is much more than mere desire. Desire may be nothing more than a strong longing, an intense wish or a craving. On the other hand, ambition, as defined by Webster is, "An uplifting desire to achieve". All ambition is not uplifting. Ambition is also defined as a strong desire for, "Power, honor, office, superiority or distinction". The Latin root of the word, ambition, means in effect, chasing after votes. Ambition has personal advancement as its objective; it may or may not be praiseworthy. Too often it is not. If a person is striving after that which is uplifting and ennobling, it should be called "aspiration", which is defined as the desire to accomplish something noble, worthy or great.

An engineer may have a strong desire to possess an authoritative knowledge of mathematics or physics. It is only a desire until he embarks on a definite program to fulfill that desire. Then it becomes an ambition or an aspiration.

It is a common weakness among human beings to desire but to refuse to make the sacrifices that are needed to bring that desire to fruition. The old expression, "If wishes were horses, beggars would ride", has much food for thought in it.

It seems that in the last two decades there has been growing sentiment among the masses that desires must be fulfilled without effort or sacrifice even if it is necessary for the state to furnish gratis the fulfillment of those desires. This false philosophy which has been expounded largely by politicians primarily to obtain votes has succeeded in fooling too many people. When the fulfillment of a desire is obtained with apparently no payment, there are many harmful effects. That which is obtained for nothing is not appreciated and valued and therefore it is not taken care of properly. Goods manufactured by the labor of earnest workers are squandered. And finally, too many people "look to the state" to furnish those things which they should furnish themselves.

There is no limit to human desires. Every attempt to fulfill them gratis by "the state" has been disastrous. National progress and production slowly grinds to a standstill when desires are filled gratis while those who sacrifice and aspire to nobler things are penalized out of existence.

There is no substitute for genuine ambition. To aspire to greater heights is a mark of noble character. But those who merely expound their desires and demand their fulfillment thereby contribute nothing to the company with which they are connected and become a terrifying drag on progress and society. The bees have a way of taking care of drones.

Trial by Torture
LIFE is too short to determine the useful life of our ball bearings under normal conditions. That is why we *accelerate* tests, by overspeed, overload, extremes of temperature, by running, under every conceivable condition of operation, day and night, year after year.
Around the clock, our engineers continue the research that has made the best bearings of yesterday even *better* bearings today.
Forty years of this searching have given us a wealth of experience that should be helpful to you. No need for trial and error. We've been all through that, for your benefit.
Nothing Rolls Like a Ball...
NEW DEPARTURE
BALL BEARINGS
NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
149

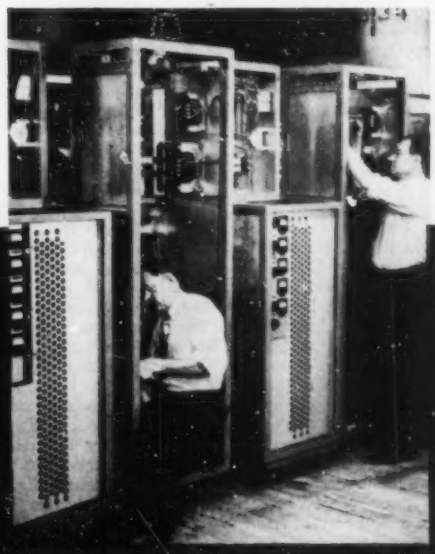


Fig. 1—Assembly of television station equipment. Engineering change notices on a component for a product such as this should specify cut-in point of change and disposition of obsoleted parts, if any.

Controlling Engineering Design Changes

ALLEN T. WILSON
Communications and Sound Sections, RCA Victor Division
Radio Corporation of America

WHEN A PRODUCT IS DESIGNED for mass production, the designer is expected not only to be a master of his product but to know intimately all phases of manufacturing, including cost estimating, production control, tool design, fabrication and processing techniques, inventory control, and assembly. While it is obvious that no one man can be a specialist in all of these phases of manufacturing, the physical characteristics of a product and the drawings for it tend to prescribe the factory's method of manufacture. As a matter of fact, the main function of drawings is to show the factory how to build and assemble a product.

But because the engineer is seldom a production expert and because no design is perfect from the functional or sales standpoint when it is initially released to the factory, a number of engineering changes always must be made during and after the product is put into production, Fig. 2. Frequently the amount of time devoted to changing a product after its release will equal the time spent on the original design, and the notices authorizing such changes often become some of the most controversial pieces of paper issued by the engineering department. Engineers whose activities have been centered entirely around theoretical designs frequently are dismayed when their designs enter a production stage that requires the issuance of change notices.

This need not be the case, however, if the engineer realizes that changes are a cost of doing business. Neither the engineering or sales departments would want to permanently freeze a design. Also, the factory has serious limitations from an engineering viewpoint in the initial stage of building any product. Until the factory has made a product for years and acquired that intangible item called "know-how", it will request changes to improve ease of production.

However, the fact that engineering changes are to be expected is no excuse for letting them go uncontrolled. To do so results in confusion and increases cost. Following are recommendations that may help the engineering department in setting up a workable design change system, particularly with respect to relations with the factory.

ESTABLISH A CLOSE ENGINEERING-FACTORY CONTACT. It is absolutely necessary that the design engineer be acquainted with production facilities and problems, or at least that he check basic considerations with production personnel. Review of engineering drawings by factory people prior to sign off is of little value in reducing the number of design changes required. Checking of preliminary prints usually is sketchy, time consuming, and uncoordinated. The preliminary review may be done by one person, while, on release, the drawing is processed by another. Then a detailed study is made of the drawing by the tool design department, process personnel, time study men, foremen, and inspectors, among others. Obviously all these people do not review preliminary prints, but their comments are

valid after the prints are released. Thus, review of drawings is helpful only when limited to a few prints and when personally followed up by the engineer with person to person contact. At this stage, though, detailed factory comments may be unwelcome by the engineer as too many related parts are affected when suggestions by factory personnel are incorporated into drawings.

Many times gross or obvious errors that are apparent to the design engineer occur in the initial production run of a product. Due to the cost of making a sample part and the resultant delay in meeting schedules, the engineer often sees such parts several days after production has begun. There are several ways to correct this situation: (1) The engineer can circulate within the factory during the initial production phase; (2) the first inspection piece can be forwarded to the engineering department for comment; or (3) a pre-production run of a number of pieces can be made to prove the design and prevent errors.

GIVE CHANGES PRIORITY. Some changes are absolutely imperative either from the standpoint of production, sales, or product operation; they must be made immediately as the situation arises. Other changes are desirable but not critical; perhaps they can be made at a time more convenient to the shop—they can be scheduled, in other words. Still other changes would result in only minor improvement in product appearance or function; to reduce cost, they perhaps can be collected and made at the time of model changeover.

Changes during a shop order follow a fairly uniform pattern. After release when parts are being procured and made, purchasing and manufacturing want alternates or deviations from drawings which may need to be confirmed by drawing changes. These changes generally involve no cost as they are prior to parts being made. Starting prior to assembly and during the initial assembly phase of the shop order, the engineering department will need changes to correct errors. These changes are the costly ones requiring scrap, reworking, or new parts. Then as the assembly plant becomes more familiar with the design during the same phase, the assembly process department and the assembly line will want changes. These changes will generally be to facilitate manufacture, assembly, processing, and stocking of parts which are required to build the product in conformance with the cheapest methods. Then as the sales department gets some of the first units and starts to get customer reaction, other changes are required. Here again these changes are costly. A problem results from the fact that the people who see and have to account for the costs of changes do not also see how the product benefits from these costs. Establishing a priority system for changes such as these will substantially reduce costs.

USE FORMS FOR TEMPORARY CHANGES. Engineering change notices are many things to many people. They actually affect as many operations or organizational units as the original drawings. Since the release of drawings usually is systematized and correlated with all organizational units, many engineers may be unfamiliar with the wide scope of their distribution. The issuance of change notices forces every engineer to become familiar with this scope.

An engineering change notice Fig. 3, is (1) an authorization to change a drawing as specified; (2) instructions to the factory as to disposition or action on the part or assemblies changed; (3) instructions to replacement parts as to disposition or action on the part changed. Other activities may also be affected such as writing of instruction books but the above three are the main ones. Of course on changes affecting the saleability or performance of the product, sales and product administration are also intimately concerned.

Engineering change notices should not be issued to cover all deviations from drawings. Deviations from drawings arise from several items. They may result from engineering errors in the drawing, intentional deviations required to produce parts which will be reflected in every part made, factory errors or unintentional deviations which are correctable, and substitutions. Engineering change notices should be written to correct all errors in the drawing, all intentional (approved) deviations from the drawing, and substitutions which are permanent or are approved alternates. Other deviations from drawings can be covered by the use of one or several simplified forms that

1. Approve use of parts from an alternate supplier.
2. Approve deviations in the first sample parts submitted by a supplier.
3. Approve temporary substitutions in materials for parts supplied by the factory.
4. Transmit engineering information to the shop.
5. Approve or reject deviations from drawings for production parts.

Whenever a temporary change is affected either a form should be used or the change should be confirmed in writing. Verbal agreements are subject to misinterpretation and often lead to subsequent controversy.

However, other factors are present. Many people will contact the engineer to cover relatively minor items or interpretation of notes and dimensions. Many of these relate to company manufacturing standards which will supplement the drawing. Unless such items affect costs or methods of manufacture, normally no drawing changes need be made.

CONSIDER PART INTERCHANGEABILITY. The biggest problem introduced by changes, except for cost and schedule, is the problem of interchangeabil-

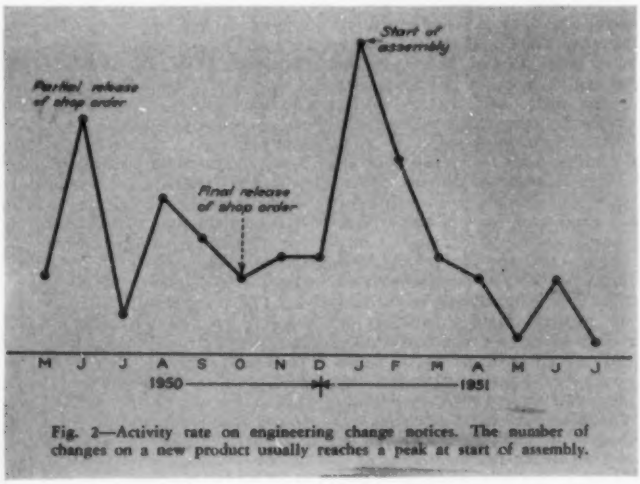


Fig. 2—Activity rate on engineering change notices. The number of changes on a new product usually reaches a peak at start of assembly.

MATERIAL DISPOSITION

ENGINEERING CHANGE NOTICE

DETAIL PARTS | ASSEMBLIES & BILLS

PLANT

MFG. 6011-1

S.O. 6011-1 R Kramer 8-4 — ESSENTIAL

COPY TO Al Malcarney 8-5 O V Swisher 15-5 — CONDITIONAL

TITLE OF EQUIP. 16mm Projectors

AFFECTS: SUB CONT. / PRIME CONT. / TRADING — SPARE PARTS LIST — INST. BOOKS — ENG. S.O. 915201-1

	CHNG. TO BE CHARGED	PT. OR ASSY.	TITLE OF DWG.	TITLE OF ASSY.	QTY.	MASTER ITEMS IN WHICH USED	DISPOSITION	DESCRIPTION OF CHANGE	STK.	FACTORY	REVISING CODE
1a			113115-508	175460	6	1312					
1b			Clutch Assembly		6	1311	S	P-23, Reel Shaft Assembly (Lower), Chg Ref 185987-505 to 185987-506	X	X	ENG
2a			118300-501	8876370	6	ditto					
2b			Reel Arm Assy. (Upper)		6		S	P-4, Reel Shaft Assembly (Upper), Chg Ref 185986-505 to 185986-506	X	X	ENG
3a								NOTE "S": Cut-in point S.O. 6011-1. New reel shafts are interchangeable with the old reel shafts. Use reel shaft assemblies made for S.O. 6011-1. If shortages exist on S.O. 6011-1, it is OK to use new reel shaft assemblies providing each projector shipped has the new reel shaft assemblies in both the upper and lower reel arms. Per R. Kramer, 8-4, cost of change is $150. for tools and no change in piece price.			
3b											
4a											
4b											
5a											
5b											
6a											
6b											
7a											
7b											

REASON FOR CHANGE: To facilitate assembly of film reel to reel shafts.

LINES WILL INCORPORATE

CONFIRMED R. W. Gilmore 17-4 (2)

R. Kem 10-6 (1)

REVISED TRACING DATE

Drafting completed

MI stock not affected

ENGR. DATE ENG. DEPT. MANAGER DATE

Fig. 3—Engineering change notice being used by one manufacturer. Note that a point is made of giving all information considered pertinent.

Fig. 4—Typical drawing change column. This should describe changes made since the factory follows these notes if reworking of parts is involved.

ity of parts. Interchangeability is a very nebulous item. First of all complete interchangeability must operate in both directions; that is, the old part must be interchangeable with the new and vice versa. There should be no preference between the interchangeable parts. There should be consideration given to costs because if the difference in costs between two interchangeable parts is great, the cheaper part is preferred. Finally consideration needs to be given process interchangeability in the fabrication plant. Two functionally interchangeable parts may require entirely different processes; one may be a casting and the other a stamping, and the parts may barely resemble one another in appearance. Special attention needs to be given replacement parts, and whenever possible, their stock problem needs to be simplified. Many times it is possible to stock the new part or several parts which will be an interchangeable unit in all products built. Notes may be used on the engineering change notice to help clarify this interchangeability problem. Because the engineering department is apt to change drawing numbers and interchangeable parts may not have the same drawing number, replacement parts may assign its own stock number to the part which is different than the drawing number. Then several different interchangeable parts can be stocked under the same number.

AVOID MARKED PRINTS. Reworking of parts made always requires some consideration of interchangeability because there is a preference between parts made to the latest drawing and parts made to a previous drawing. However, since the factory usually does not maintain its stock by change number, a change involving rework may be a difficult thing to handle. The assumption can be made that all parts to the same drawing number are interchangeable. When two or more parts must be correlated on a rework, it is generally easier to change part numbers just to accommodate the factory. At all times, the engineer must base his disposition instructions on the assumption that all parts are made.

The change column on the drawing Fig 4 should completely describe the drawing change as the factory follows those instructions to rework. If reworking parts made is not to be accomplished in accordance with the desired drawing change, the rework must

be specified on the engineering change notice. This should be by means of a note or a sketch. The engineer must particularly mastermind any rework instructions. Costs and schedule are the two considerations. In some cases it is cheaper to scrap parts made and make new parts. If this is so, such action must be specified.

Reworking parts usually involves moving in on the change fast and supplying the factory with new prints immediately. Marked prints are to be avoided for several reasons. (1) they are hard to "kill". Instances have been known where marked prints were in use for several years. (2) They are not applicable to extensive changes correlating several parts. (3) They are only applicable to minor changes in a part. Extensive changes require a new print as duplicating several marked prints involves too many opportunities for error and requires more time than changing the print. (4) Marked prints cannot be recorded thus they may be duplicated by unauthorized individuals.

SPECIFY CUT-IN POINTS AND PART DISPOSITION. The changing of assembly drawings is far more complex than changing detailed part drawings. One particular problem results from the fact that many normal changes on an assembly drawing actually are "future" changes. For instance, if a detailed part on an assembly drawing is changed and the parts made are usable, then the assembly drawing does not reflect the product as it is being currently produced. This same situation occurs when parts are changed and the new parts are not immediately available. Or this same situation can occur when the change requires the reworking or salvaging of parts and the resulting part or parts are not like when they would be if they were made from raw material.

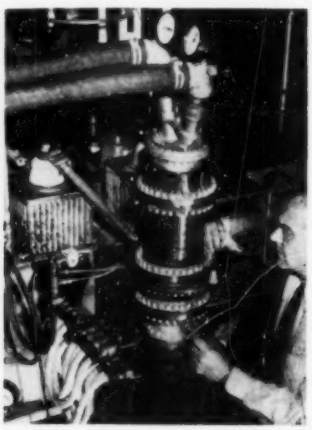


Fig. 5—New 500 kilowatt high vacuum "super-power beam Triode" now in production. On a development such as this, the factory is handicapped in that it is not initially well acquainted with the product. Having engineers well versed in factory methods is the best way of reducing changes for manufacturing reasons.

Therefore, the engineering change notice on an assembly should specify not only the cancelling of parts on a shop order, reducing the quantity of parts, or adding new parts, but also the disposition of parts that have been obsoleted and the point at which the factory is to cut-in with the change. Sales needs this information to know when important changes are cut-in. Manufacturing needs it to maintain a semblance of continuity of scheduling and control of costs. Replacement parts needs it so they will know 10 years from now what part to supply a customer, and Engineering needs it so that they can coordinate the change.

Definite pre-assigned cut-in points should be established upon economical production quantities, and should consider the assembly rate. Only "stop" production changes should be allowed at other times, and such changes should require approval by the top level of sales, product manufacturing and engineering.

Such a procedure reduces costs of changes and solves the interchangeability problem as units within any cut-in point can be assigned different model numbers. Thus upon release of a shop order the model number dash 1 might apply to the first two thousand units, and dash 2 might apply to the second two thousand units, etc. By pre-assigning these numbers and by accumulating the engineering change notices for cut-in at these points, much confusion would be resolved in the shop, and to some extent, in the engineering department.

Changes involving vendor's requests, factory's requests, or engineering errors can be cut-in at any time, providing (1) no increase in costs are incurred (2) no change in parts are involved or (3) no change in the assembly line is involved.

During the first cut-in point period, strict adherence to this proposal may not be possible as this is the period for indoctrinating know-how into the factory personnel and proving the design.

One of the difficult problems occurs when the factory is building one shop order and engineering is working on an evolutionary design based on the same product drawings. Changes may be desired in a part currently in production. If the part is changed for the new shop order, but not the old, then the factory may be in the position of trying to build a part different from the delineation. This is a "future" engineering change notice and should not be used. However, whenever a change is made and the engineer specifies the disposition "Use Parts Made", the engineering change notice is essentially a future engineering change notice. In these cases there is generally no preference between parts made to either sub on the drawing. To avoid future engineering change notices, it may be advisable to add new parts to the drawing or to make a new drawing. Thus it can be seen that in some respects, drawings apply to one shop order only.

Cooperation Is the Keynote

Summing it all up then, the nuisance of engineering changes can be greatly reduced if: (1) engineers become more familiar with factory operation; (2) a system is set up that is realistic toward changes and that all personnel involved admit that changes are normal; (3) the first new piece on every shop order is submitted to the engineering department for approval —and this can easily be done since a sample can be made during the tool trial before the tool is forwarded to production; (4) pre-production runs are made whenever possible; (5) a method is established that will allow the systematic assimilation of changes into a production order; and (6) detailed disposition of obsolete parts and assemblies as well as cut-in points are indicated to all departments that will be affected.

All of this points out that the manufacture of a product within a factory is a great cooperative effort. In some respects the engineer is the unifying force between the individuals within the factory. Many times he becomes the arbitrator when differences arise—and the cohesive force to tie the loose ends together. He can build a product consciousness in the minds of everyone which will overcome the departmentalism inherent within the factory. Or he can destroy the cooperative viewpoint by his failure to work with or cooperate with various individuals on their requests to ease their jobs. The adoption of suggestions and changes from factory personnel will help sell the product to the organization. The success of any product depends largely on how successful the engineer is in accomplishing this factor. In this way the engineer attains the authority that is required to discharge his responsibility.

Minnesota Mining and Manufacturing Co.

Fig. 1—Adhesive being applied to the metal ceiling of a custom-built taxicab in first step in the installation of roof panel silencer pads. After spraying, pads are pressed in place. No mechanical fasteners are required.

Selecting Engineering Adhesives

FRANK W. REINHART*
National Bureau of Standards

ADHESIVES, once seldom considered for joining parts in a primary load carrying structure, have changed completely in character these past few years. Properly applied, they are capable of bonding metal to metal, metal to plastic, or these with combinations of other materials with an efficiency equal to that obtainable with other joining techniques—and often at less cost.

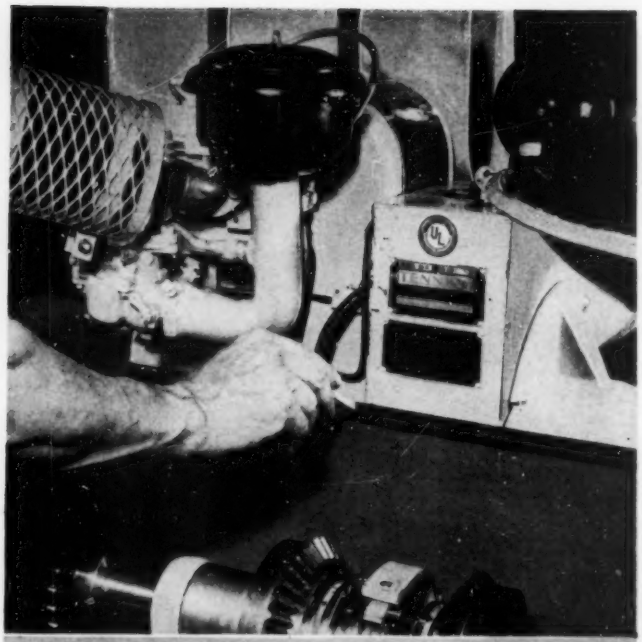
This change has resulted from the advent of new adhesive materials, particularly the synthetic resins; and from an increasing knowledge of the fundamentals of adhesion, of factors affecting the permanence of bonded joints, and of application techniques.

There are several methods for classifying adhesives. In one system adhesives are classified according to the general chemical type similar to that used for plastics, resins, and rubbers. This is shown in Table Ia.

The classification of adhesives according to general classes of materials to be bonded is not satisfactory for some types of materials such as metals, plastics, and rubbers because of the great variation in bonding characteristics among specific members of each general type. For example, an adhesive suitable for brass is not always satisfactory for steel. One suitable for cellulose nitrate plastic may be of no value for phenolic plastics.

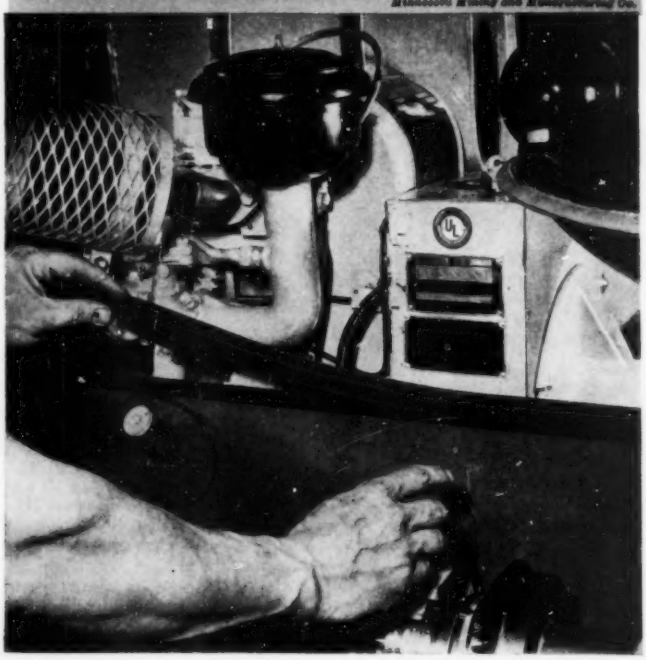
However, the variations in bonding characteristics among members of other general classes of materials such as glass, wood, paper, leather, and fibrous organic materials are not great so that these terms can be used in a classification scheme with some degree

* The opinions expressed in this article are those of the author and do not necessarily reflect the attitude of the U. S. government.



Felt and other cushioning materials, bonded to metal surfaces by adhesives, find application in machinery as vibration dampers. Above, adhesive is applied to metal by brushing. Felt strip, below, need only be applied by light finger pressure to obtain a satisfactory bond.

Minnesota Mining and Manufacturing Co.



of satisfaction. This scheme will not be considered here.

Another method classifies adhesives according to the temperature required to produce a good bond. The limits defined by American Society for Testing Materials Committee D-14 on Adhesives are shown in Table Ib (1). This system might be considered to be one part of a broader classification scheme based on the method by which the adhesive changes from the liquid to the solid or pseudo-solid state. This is shown in Table Ic. The classes in Table Ib may be considered as subclasses under Class IV of Table Ic.

Another system of classification suggests itself, that is, one based on the type of adhesive bond involved. So little is known about the types of bonds, particularly in specific assemblies, that it is difficult to judge whether or not it is possible to devise such a system.

It is obvious however that none of these systems of classification are entirely adequate. Experience has shown that the one based on chemical type as shown in Table Ia is probably the most satisfactory.

One of the most intriguing and elusive problems in the field of adhesives is why one material adheres to another. This problem is particularly difficult because no experimental methods for measuring the strength of adhesives bonds directly are known. There is good indication that ultrasonic methods such as those being developed at the Massachusetts Institute of Technology and the Naval Research Laboratory may help solve this problem.

It is apparent however that chemical forces are the predominant factor causing adhesion. There are several types of chemical forces but for the purposes of adhesion they may be classed into two groups, namely, (a) primary valence forces which are the stronger, and (b) secondary valence forces which are the weaker and probably the most common type encountered in adhesion. These have been discussed in detail by Rinker and Kline (5) and Kline and Reinhart (6).

However, the actual strength of a specific adhesive bond is the resultant of many factors. These factors may be classified into four groups, namely, A) those causing adhesion, B) those determining initial degree of adhesion, C) those causing stress on the adhesive bond, and D) those determining the degree of stress on the adhesive bond, as shown in Table II. This classification is based on the premise that adhesion is caused primarily by chemical forces and that the physical factors concerned determine the extent

to which the potential of the chemical forces is operative in the bond strength. The relations between the bond strength and these classes of factors may be expressed, in general, as follows:

$$\text{Bond strength} = AB - CD$$

This may be interpreted as follows. The factors in class *A* cause adhesion while those in class *B* determine the degree to which the factors in class *A* are operative. The factors in class *C* cause stresses on adhesive bonds while those in class *D* determine the magnitude of the stresses arising from the factors in class *C*.

In the formation of an adhesive bond, the adhesive and the adherend must be brought into sufficiently close contact over the bond area so that the chemical forces initially responsible for the bond strength become operative. This requires that the adhesive become liquid or that it be synthesized in contact with the surfaces of the adherend. The techniques for obtaining a liquid state involve the use of solvents, heat, pressure, and combinations of these. The classification of adhesives in Table I, is based on the technique of obtaining the degree of nearness for bond formation. Certain types of viscous adhesives probably remain in a high-viscosity liquid state but such materials have low strengths and high flow properties. Since the base strength depends on the number of chemical bonds formed in any one system, the surfaces of the adherend must be clean so that the adhesive, provided it is in the proper state, can achieve the requisite molecular nearness and sufficient adhesive must be present to fill the volume between the adherend surfaces completely.

When the liquid adhesive changes to a solid or pseudo-solid state, a contraction in volume occurs which produces stress on the bond, the amount of stress depending on the moduli and plastic flow of the adhesive and adherend, the design of the joint, and the thickness of the adhesive. The ratio of coefficients of thermal expansion of the adhesive and the adherend is also effective on cooling adhesives which are set by heat and on changes in temperature in service. Many adhesives and some adherends change in molecular structure on aging, in water content, or in plasticizer and solvent content which may cause changes not only in volume, moduli, and plastic flow but also in bonding strength. Irregularities such as abrupt changes in contour, pits, or scratches on the surfaces of the adherend cause stress concentrations and pockets for air bubbles to be trapped in the bonding opera-

Table I—Classification of Adhesives

(a) ACCORDING TO CHEMICAL TYPE

General Chemical Type	Specific Chemical Type[a]	
I. Synthetic thermoplastic	Acrylate	Vinyl alcohol
	Styrene	Vinyl chloride
	Alkyd	Coumarone-indene
	Vinyl acetate	Modified waxes
	Vinyl acetal	Vinyl butyral
II. Synthetic thermosetting	Phenolic	Polyester
	Resorcinol	Isocyanate
	Malamine	Silicone
	Urea	Epoxy
	Furan	
III. Cellulose derivative	Cellulose nitrate	Hydroxyethyl cellulose
	Cellulose acetate	
	Cellulose propionate	Carboxymethyl cellulose
	Cellulose acetate butyrate	
	Ethyl cellulose	Methyl cellulose
IV. Rubber	Natural	Butadiene-styrene
	Reclaimed	Butadiene-acrylonitrile
	Neoprene	Cyclized rubber
	Isobutylene	Chlorinated rubber
	Thiokol	
V. Protein	Casein	Soluble dried blood
	Soybean	Blood albumen
	Animal (glue)	Zein
VI. Starch (Paste)	Starch	
	Dextrin	
VII. Oleoresin		
VIII. Shellac		
IX. Bitumens		
X. Vegetable gum (mucilage)		
XI. Mineral	Oxychloride	
	Silicate	
XII. Metal	Lead solder	
	Silver solder	
	Brazing compounds	

[a] The items given in this column do not purport to include all the specific types falling under the general type or to be the ultimate in specificity.

(b) ACCORDING TO SETTING TEMPERATURE

Class of Adhesive	
I. Cold-setting	Below 20 C (68 F)
II. Room temperature setting	20 to 30 C (68 to 86 F)
III. Intermediate temperature setting	31 to 99 C (87 to 210 F)
IV. Hot-setting	Above 99 C (210 F)

(c) ACCORDING TO METHOD OF CHANGE FROM LIQUID TO SOLID OR PSEUDO-SOLID STATE

Class of Adhesives	Cause of Change from Liquid to Solid
I. Solvent-sensitive	Evaporation of solvent
II. Pressure-sensitive	Release of pressure
III. Temperature-sensitive	Decrease in temperature
IV. Reaction-sensitive	Chemical reaction activated by catalysts or heat or both

Fig. 3—A die-cast aluminum tank bottom and a lead coated sheet metal tank-turn-plate for an outboard motor being crimped together in a pneumatic press. The two parts are bonded first with adhesive to insure a good bond despite the use of a follow-up crimping operation.

Table II—Adhesive Bond Strength Factors

A. Factors causing adhesion
1. Primary valence bonds
2. Secondary valence bonds

B. Factors determining initial degree of adhesion
1. Physical state of adhesive during bond formation
2. Cleanliness of surface of adherend
3. Quantity of adhesive

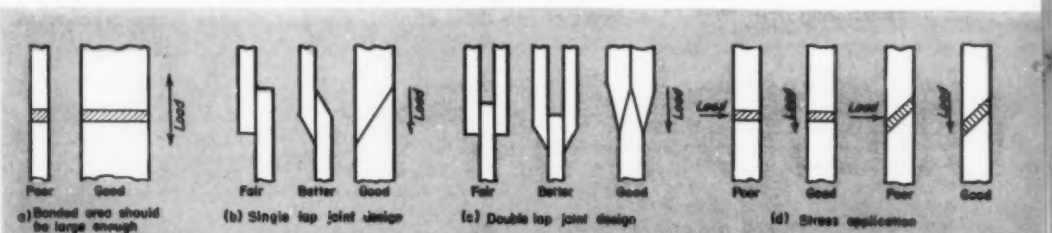
C. Factors causing stress on adhesive bond
1. Changing from liquid to solid or pseudo-solid state
2. Changes on aging
3. Changes in temperature
4. Changes in water content
5. Changes in composition
6. Character of surface
7. Application of external load

D. Factors determining degree of stress developed on adhesive bond
1. Modulus of adherend
2. Modulus of adhesive
3. Plastic flow of adherend
4. Plastic flow of adhesive
5. Design of joint
6. Thickness of adhesive
7. Ratio of coefficients of thermal expansion
8. Soundness of surface of adherend

tion. The external load which a bond will sustain before failure is not only dependent on the inherent strength and the internal factors causing stress but also on the moduli and plastic flow characteristics of the adhesive and adherend, the design of the joint, the thickness of the adhesive, and the soundness of the adherend surface.

A study of the interrelations of the factors in Table II indicates that there should be some correlation between the values for some of these factors and the measured strength values of bonded assemblies. Perfect correlations cannot be expected because the magnitude of the effect attributable to each factor may vary differently in different systems of adhesive and adherend.

Some relations between modulus values and adhesion as expressed in tensile and shear strengths appear to hold (7). Low strength values are obtained when the modulus values of both adhesive and adherend are low. Combinations of high modulus mate-



One of the principal causes of failure in adhesive applications is poor engineering design of bonded assemblies. Some of the design factors which should be considered are as follows:

(1) Adherends should be selected of such materials and size that cohesive failures do not occur.

(2) The assembly should be designed so that a sufficiently large bonded area is obtained as indicated in (a).

(3) The assembly should be designed if possible so that the bond is loaded in shear rather than in tension. The strength of a given bonded assembly decreases in the following order: shear > tension > cleavage or peel. In a few cases tension may exceed shear.

(4) The better design of single lap shear joints is shown in (b) and of double lap shear joints in (c). The angle of the tapered ends depends upon the moduli of the adherends.

(5) Bonded joints should not be loaded, if possible, so that the bonds are subjected to high cleavage forces, (d) or to high peel forces (e). Angle a should be as large as possible.

(6) Uniformity in thickness of the adhesive layer, illustrated in (f), is usually preferred for high strengths because irregularities create points of stress concentrations.

(7) The layer of adhesive should be kept as thin as possible, (g), to obtain the highest tensile and shear strengths. An increase

Table III—Tensile and Shear Strengths of Adhesive-Adherend Combinations

Adhesive	Strength	Adherend					
		Stainless steel, psi	Aluminum alloy, psi	Paper laminate phenolic, psi	Glass, psi	Birch wood, psi	Hard rubber, psi
Cellulose nitrate	Tensile	2180	1500	860	1080	1100	590
	Shear	1580	1360	1680	1680	1390	1000
Polyvinyl acetate	Tensile	3600	3270	1060	2430	960	400
	Shear	2960	3560	2480	2310	1990	630
Resorcinol resin	Tensile	0	0	830	0	1180	1340
	Shear	0	0	1570	0	1940	590
Casein	Tensile	510	110	690	0	1020	130
	Shear	190	120	1030	29	1660	150
Gum arabic	Tensile	110	110	630	260	400	320
	Shear	130	330	440	280	630	240
Rubber	Tensile	260	390	160	34	170	130
	Shear	270	250	130	45	160	190
Neoprene	Tensile	170	290	170	90	3[illegible]	240
	Shear	90	130	250	100	[illegible]0	230

rials also give low strength values. Combinations which include at least one material of medium modulus exhibit the highest strengths. In loading assemblies made with either a low modulus adhesive or adherend, the stresses are concentrated at the bond between the highly elongated and the slightly elongated materials. When both adhesive and adherend have high modulus values neither material flows sufficiently during the final stages of the bonding process to relieve the stresses developed.

Selection of Adhesive

The variations in the strength obtained between specific adhesive-adherend combinations preclude the development of general rules for selecting adhesives for specific applications. The only reliable method is laboratory evaluation and test. However, some principles which can be used to plan the selection procedure are as follows:

High strength bonds can be obtained with adhesives that dissolve slightly or attack the adherend. The bond formed constitutes a welding or intermingling of the materials of the adherend and the adhesive. The two materials must be compatible to obtain a good permanent bond by this technique. Care must be taken that for thin adherends the adhesive does not penetrate completely through and thereby reduce the cohesive strength. Crazing or surface cracking might also result with some types of plastics.

Materials which have a high ratio of real to apparent surface area, such as wood, paper, and textiles, are bonded readily with a wide variety of adhesives. Part of this is attributed to the fact that most of these materials contain cellulose to which many materials adhere readily.

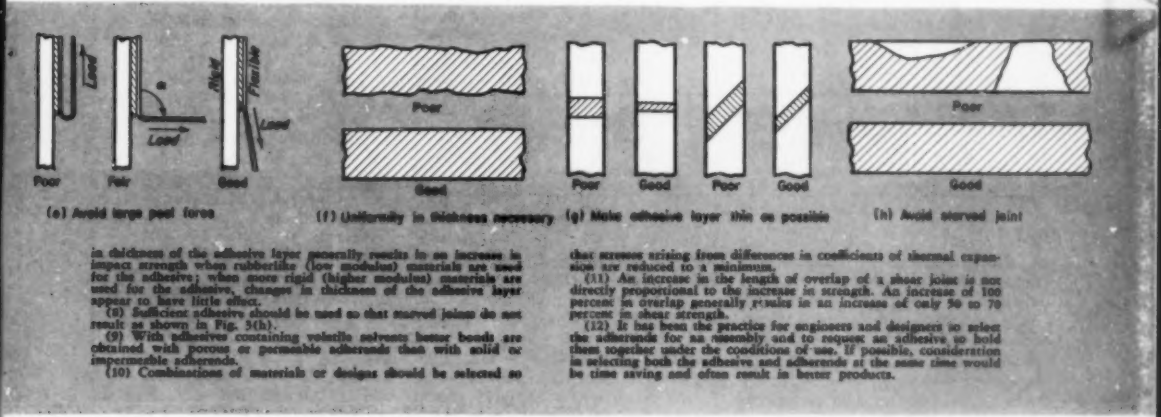
Heat-cured bonds, made with both thermosetting and thermoplastic adhesives are generally stronger than others.

Thermosetting adhesives are usually stronger and are more resistant to heat, water, and chemicals than thermoplastic adhesives.

Adhesives with a low modulus of elasticity, such as the pressure-sensitive types, have low strengths, high creep rates, and often poor aging properties.

Adhesive joints fail at much lower stresses on long time loading than in short time loading; the lower the modulus the greater the difference.

It is very difficult to obtain high strength bonds with materials, particu-



(e) Avoid large peel force (f) Uniformity in thickness necessary (g) Make adhesive layer thin as possible (h) Avoid starved joint

in thickness of the adhesive layer generally results in an increase in impact strength when rubberlike (low modulus) materials are used for the adhesive; when more rigid (higher modulus) materials are used for the adhesive, changes in thickness of the adhesive layer appear to have little effect.

(8) Sufficient adhesive should be used so that starved joints do not result as shown in Fig. 5(h).

(9) With adhesives containing volatile solvents better bonds are obtained with porous or permeable adherends than with solid or impermeable adherends.

(10) Combinations of materials or designs should be selected so that stresses arising from differences in coefficients of thermal expansion are reduced to a minimum.

(11) An increase in the length of overlap of a shear joint is not directly proportional to the increase in strength. An increase of 100 percent in overlap generally results in an increase of only 50 to 70 percent in shear strength.

(12) It has been the practice for engineers and designers to select the adherends for an assembly and to request an adhesive to hold them together under the conditions of use. If possible, consideration in selecting both the adhesive and adherends at the same time would be time saving and often result in better products.

Table IV—Bond Strength of Adhesives to Metals

TENSILE

Adhesive	Adherend	Tensile Adhesion Strength, ASTM D 897 or similar	
		73 F, psi	400 F, psi
Phenolic-elastomer A	Anodized Aluminum	3400	.....
B		700	.....
Phenolic A	Anodized Aluminum	3300	.....
Polyvinyl butyral A	Anodized Aluminum	6700	.....
Phenolic-A-butyral A	Anodized Aluminum	4000	.....
Polyvinyl acetate	Anodized Aluminum	3800	.....
Epoxy A	Anodized Aluminum	1900	.....
B		3100	.....
C		2300	.....
Phenolic B	Steel	4000	60
C		3400	20
D		240	160
E		1350	80
F		2300	50
Alkyd A		1200	.....
B		1800	.....
C		3100	350
D		810	.....
Epoxy D	Aluminum alloy	8700	.....

SHEAR

Adhesive	Adherend	Tensile Shear Strength, ASTM D 1062 or similar			
				After 200 hr at 400 F	
		73 F, psi	400 F, psi	73 F, psi	400 F, psi
Phenolic-elastomer	A Aluminum	2180	220	1110	230
	B Aluminum	1600	600	70	6
	B Stainless steel	2500	.....	.....	.....
	C Aluminum	1780	40	530	280
	D Aluminum	2210	420	130	10
	E Aluminum	3370	610	2470	970
	F Aluminum	4510	440	3180	1060
	F Steel	2650	590	4280	1280
	G Aluminum	610	.....	.....	.....
	G Stainless steel	1100	.....	.....	.....
Polyester A	Aluminum	1120	190	810	250
B		1720	240	540	180
C		2190	140	2300	190
Phenolic A	Aluminum	870	340	.....	.....
B		870	370	530	660
C		640	190	310	650
D		430	240	100	240
E		690	620	1000	650
F		890	1020	.....	.....
G		180	120	120	30
Epoxy A	Aluminum alloy	8100	4100	(210 F)	.....
A	Steel	6900	.....	.....	.....
A	Stainless steel	7700	.....	.....	.....
A	Copper	7000	.....	.....	.....
A	Brass	7600	.....	.....	.....

larly organic, that are outstanding in their resistance to chemicals. No strong adhesives are known for polyethylene and polytetrafluoroethylene. Adhesives made with organic solvents do not bond well to glass but those in an aqueous alkaline medium, such as sodium silicate, do bond well.

In the selection of adhesives attention must be given to the effect the adhesive may have on the adherend. For example, adhesives containing cellulose nitrate have a deleterious effect on cellulosic materials such as paper and cotton; alkaline adhesives corrode aluminum; adhesives with either high or low pH affect cellulose and wood.

Soft mastic type of adhesives should be selected for applications where large areas likely to move, warp, or twist are to be bonded. The soft adhesive flows to relieve the stresses created when the parts of the structure move. As expected, these adhesives are not suitable for sustaining high stresses since they creep and flow under stress.

One of the major factors that causes engineers to decide against the use of an adhesive for an apparently good application is the variability in strength of seemingly identical bonded parts or specimens. This variability in most cases can be traced to variations in the bonding procedure. A discussion of some of the common mistakes should be useful.

The surface of the adherend must be clean and sound. The use of chemicals for removing grease, wax, and oil is recommended. The removal of scale and oxide layers by abrading, and sanding, is also necessary unless they are strongly bonded and tests have shown that the adhesive bonds well to them. The presence of absorbed materials such as industrial gases and water vapor often affect the adhesion adversely. This might be summarized in one sentence, "Make sure the adhesive is bonding to what you think it is."

In the case of low modulus materials, slight roughening of the surface may increase the strength by increasing the bonded area. Frequently, sanding or grinding the surface increases the strength by changing the character of the bonding surface rather than by increasing the roughness. A good example is the removal of the layer of phenolic resin from the surface of a cotton laminate or a molded woodflour-filled part. Higher bond forces are usually obtained between cellulose and adhesives than between phenolic resin and adhesives. Also fresh wood surfaces give stronger bonds than surfaces which have been in contact with air; the surfaces probably oxidize on standing in air and consequently change character.

The adhesive should be used according to the directions developed in the laboratory or recommended by the manufacturer. Strict attention to spreading details, adhesive thickness, pressure and temperature for the proper period of time for bonding, and subsequent aging is essential in most cases.

It is not possible to give a very complete summary of the properties of various types of adhesives for various adherends under a wide range of conditions, but some examples should help to give a rough idea of what can be expected of adhesive bonds.

High strength and outstanding du-

rability are the usual requirements for satisfactory metal adhesives. The most successful type of adhesive developed to date for metals is the phenolic-elastomer type. Some other types bond strongly to metals but they are mostly thermoplastic in nature with consequent poor resistance to heat, creep, and flow. The thermosetting adhesives usually have the required durability but not the required adhesive strength. The combination of thermosetting resins with thermoplastic resins appears to give an adhesive with the better properties of the two types. The higher strength adhesives of this type require the application of heat and some pressure to obtain the best properties. The strengths of a few metal adhesives are shown in Table IV.

Plastics present the widest variation in bonding characteristics. Most thermoplastics are readily bonded with solvents or solvent type adhesives to give joints nearly as strong as the adherends. The adhesive recommended is of the same or closely related chemical type as the adherend. The strengths obtained with five techniques for bonding methyl methacrylate and styrene plastics are shown in Table VI. Thermosetting materials are more difficult to bond than most thermoplastics but good bonds can be obtained.

It is also difficult to obtain high strength bonds with glass. Silicate adhesives are the most satisfactory.

Table V—Impact and Shear Strengths of Brass Bonded to Surface Sanded Molded Phenolic Plastic with Various Adhesives

Adhesive	Primer on Brass	Impact Strength, ASTM D 950, ft-lb	Shear Strength, ASTM D 1002, psi
Synthetic rubber A	None	4	50
B	None	2	100
C	None	4	60
Vinyl plastic	None	5	30
Thiokol	None	6	90
Resorcinol	Phenolic-elastomer C	7	900
	Phenolic-elastomer D	7	700
	Synthetic rubber A	7	500
	Vinyl plastic	6	200
	Synthetic rubber C	6	400
	Phenolic-elastomer F	5	1000
Phenolic	Phenolic-elastomer C	6	1000
Phenolic-elastomer A	Phenolic-elastomer E	5	1000
B	Phenolic-elastomer D	7	1100
Furan	Phenolic-elastomer D	5	600

Table VI—Tensile Strength of Bonded Methyl Methacrylate and Styrene Plastics

Adhesive	Adherend	Tensile Strength, ASTM D 897, psi
I. Friction welding	Methyl methacrylate	2230
	Styrene	2200
II. Solvent bonding		
Acetone	Methyl methacrylate	1520
Acetone	Styrene	1770
Benzene	Methyl methacrylate	0
Benzene	Styrene	1620
Methyl acetate	Methyl methacrylate	2560
Methyl acetate	Styrene	2770
Ethylene dichloride	Methyl methacrylate	2560
Ethylene dichloride	Styrene	2220
III. Monomer bonding		
Catalyzed methyl methacrylate	Methyl methacrylate	3300
IV. Bonding with solution of adherend		
20% solution in ethylene dichloride	Methyl methacrylate	4570
20% solution in methyl acetate	Methyl methacrylate	3530
20% solution in ethylene dichloride	Styrene	1870
20% solution in methyl acetate	Styrene	2530
V. Solution bonding		
10% solution polyvinyl acetate in ethanol	Methyl methacrylate	4900
10% solution 18% hydrolyzed polyvinyl acetate in ethanol	Methyl methacrylate	2800
10% solution polyvinyl butyral in ethanol	Methyl methacrylate	3700

Acknowledgments

The original data on strength of adhesive bonds reported here were obtained by Margaret A. Fisher, A. G. Roberts, Beatrice D. Loos, and N. J. DeLollis of the Organic Plastics Section, National Bureau of Standards.

REFERENCES

(1) American Society for Testing Materials Tentative Definitions of Terms Relating to Adhesives D 907-49T. A.S.T.M. Standards on Adhesives. (January 1950).

(2) Maxwell, Shear Strength of Glue Joints as Affected by Wood Surfaces and Pressures. *Trans. A.S.M.E. 67*, 104 (1945).

(3) Browne and Truax: The Place of Adhesion in the Gluing of Wood. *Colloid Symposium Monograph 4*, 258 (1926).

(4) Control of Conditions in Gluing. Forest Products Laboratory Report No. 1340 (October 1941).

(5) Rinker and Kline: Survey of Adhesives and Adhesion. N.A.C.A. Technical Note No. 989 (August 1945); *Modern Plastics 23*, 153 (October 1945); 164 (November 1945).

(6) Kline and Reinhart, Fundamentals of Adhesion. *Paper Trade Journal 129*, 29 (December 29, 1949).

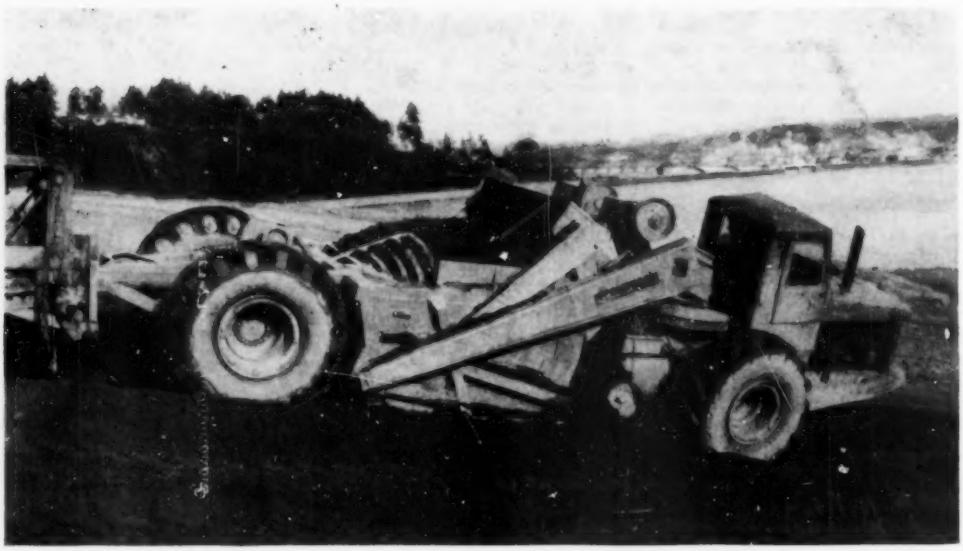
(7) DeLollis, Rucker and Wier, Comparative Strengths of Some Adhesive-Adherend Systems. N.A.C.A. Technical Note No. 1863 (March 1949).

(8) A.S.T.M. Standards on Adehesives. (January 1950).

(9) Kline, Reinhart, Rinker, and DeLollis, Effect of Catalysts and pH on Strength of Resin-bonded Plywood. *J. Research NBS 37*, 281 (1946). Research Paper RP1748.

(10) Perkins, Predicting the Durability of Exterior Plywood. Paper presented at the *First Pacific Area National Meeting* of the A.S.T.M. October 10-14, 1949.

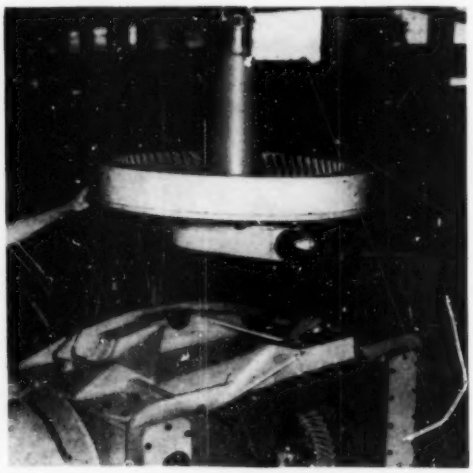
(11) Moser, Some Fundamentals of Glass Adhesion. A.S.T.M. Bulletin No. 150, 51 (January 1948).



POWER STEER UNIT of this earthmover permits the prime mover and trailer to tilt independently up to 30 deg in opposite planes when working over uneven ground and at the touch of a button provides positive steering with turns up to 90 deg in either direction. It consists of a heavy duty ring and pinion gear driven by a single speed electric motor combined with a horizontal and vertical king pin arrangement. The ring gear is bolted horizontally to the prime mover inside the steering housing. This circular housing is mounted horizontally behind the cab as shown above. The motor-driven pinion is mounted vertically on the scraper. When steering button is pushed either right or left, the pinion pivots the ring gear and the prime mover about the vertical king pin in the direction desired. Limit switches automatically cut the power when an extreme turning position is reached.

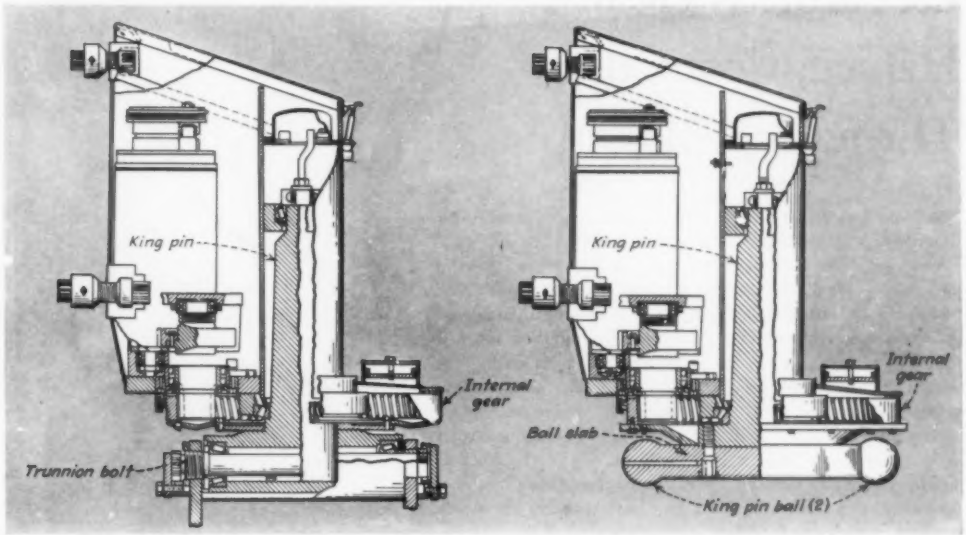
Powersteer Unit Uses Ball-Socket Design

Replacing a trunnion type mount with a simple ball and socket has resulted in more efficient operation and lower manufacturing costs for the steering assembly of the Tournapull earthmover which is manufactured by R. G. Le Tourneau, Inc. of Peoria, Ill. Diesel powered prime movers that develop up to 186 hp permit the Model C to haul 13.5 cubic yards of material (capacity 16 tons) at speeds up to 35 mph over almost any kind of terrain. Steering system is a positive type unit driven by a three phase induction motor and controlled by pushbutton switches located on the dashboard. A spring-loaded, disk-type brake on each motor is automatically applied when the switches are released. The brake automatically releases the instant power is again applied.



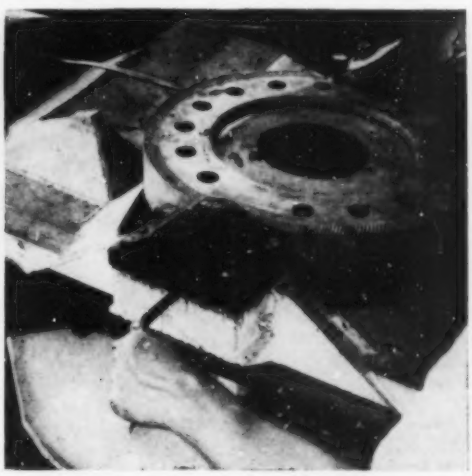
KING PIN ASSEMBLY with internal steering gear attached is lowered into place on the main case of the prime mover. Horizontal king pin slab has a ball on either end which fit into two sockets on the main case.

IN NEW PRODUCTS



BEFORE THE REDESIGN was effected, oscillation was achieved with a large trunnion bolt (left) which rode in bearings at each end and served as a connecting link between the steering assembly and the main case of the prime mover. The bolt, approximately 2.500 in. in dia and $29\frac{3}{16}$ in. long, was made from a thru-hardened forging. It had to be threaded at both ends for the locking nuts and finish-ground for the bearing surfaces. The ball and socket design (right) retains the vertical king pin that was used previously and still serves as the link connecting the trailer and prime mover. It has the same oscillation advantages as the trunnion bolt, eliminating entirely the bolt and bearing arrangement, provides a stronger steering assembly, adds to the lives of the component parts, and saves between 50 and 100 dollars in manufacturing costs per machine, depending on size.

SOCKETS into which the two balls at either end of the king pin slab fit are bronze shells approximately 0.109 in. thick. Balls are locked into these sockets by caps (right) which are bolted to the prime mover main case.

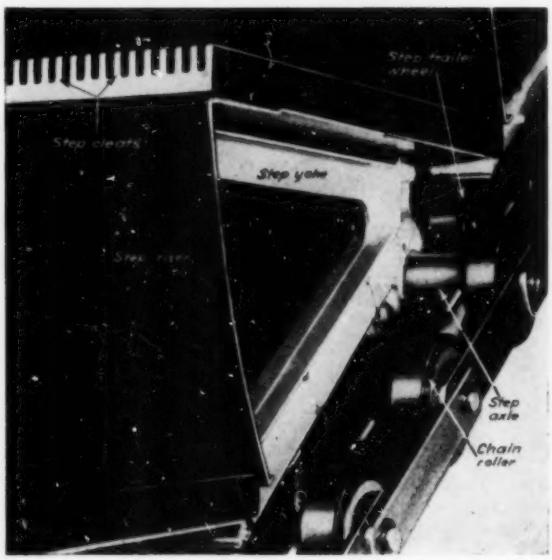


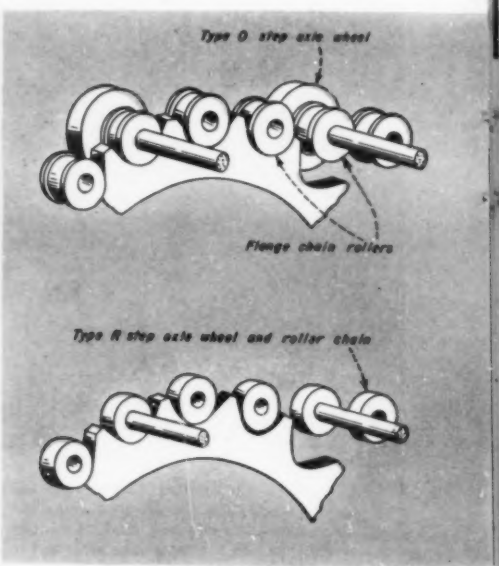
HORIZONTAL KING PIN SLAB is shown in position on the main case with the steering gear removed. Slab acts as a horizontal pivot for the steering assembly, permitting the trailer and prime mover to tilt independently.

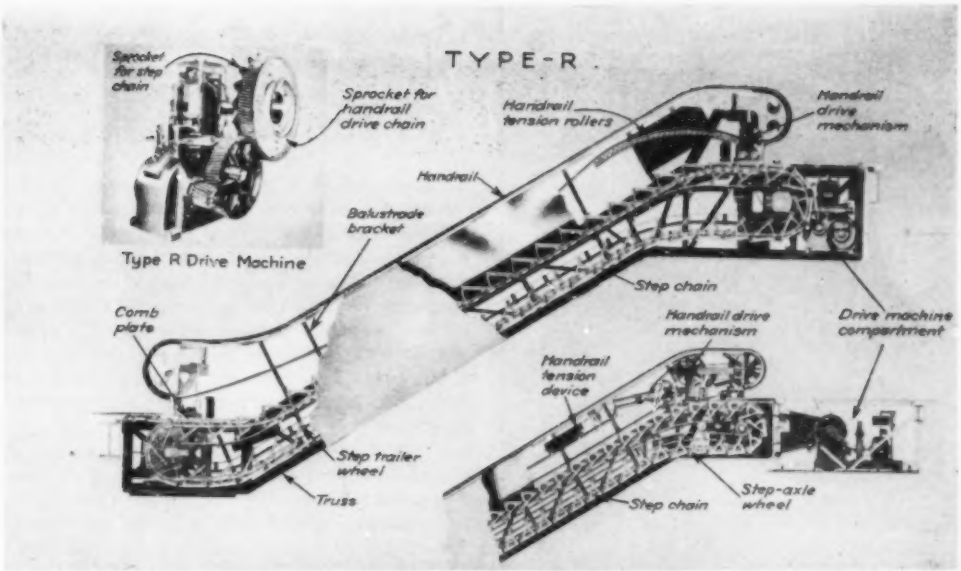
Escalator Weight Halved, Cost Cut Through Redesign

The Type R escalator has been developed by the Otis Elevator Company to fill the need for a limited-rise, lightweight, moderate-cost moving stairway for use in buildings where escalators are generally considered economically impractical. The new escalator is based on the present Type O which is designed for high-rise, heavy-duty service in such locations as railroad terminals where rises may be as high as 60 ft. By setting the maximum rise of the Type R at 23 ft, S. G. Margles, Otis engineer, has been able to use materials, design techniques and manufacturing processes that substantially reduce costs and cut the overall weight in half. Simplicity of construction and operation characterizes the design of the driving machine, controller, step chains, track system, track brackets, balustrade brackets, newel stands, safety devices, truss and floor plates. As double-duty members, the chain wheels support the load as well as transmit power, and the step axles serve also as chain pins. The load per chain wheel on the Type R escalator is only one-third that of the Type O conveyor because, on the type R unit, there are three times as many chain wheels supporting the load at the upper landing track curves where the applied load reaches its maximum value.

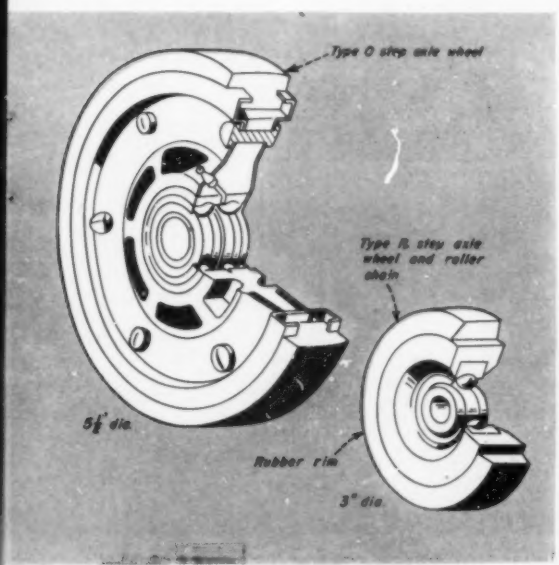
TYPE R ESCALATOR is designed for rises from eight to 23 ft. at the standard 30-deg inclination. Steps travel at rate of 90 ft per min. Width between hand rails can be made either 32 or 48 in., depending on the local traffic conditions. Step risers are porcelain enamel on sheet metal rather than stainless steel. The black enamel has less glare, better appearance, and a lower coefficient of friction than does stainless.







TYPE O DRIVING MACHINE is housed in a separate room provided by the user; whereas the Type R machine room is located within the three-piece truss, but not in the escalator body itself. Type O drive is connected to the main drive shaft through a chain and sprocket reduction mechanism. The emergency brake, which stops and holds the escalator in the event of a breakdown, must be mounted on the main drive shaft rotating at 10 rpm. Because the motor shaft operates at 900 rpm, the Type-O brake must have 90 times the torque it would require if mounted on the motor shaft. Main drive shaft of the Type R is direct-connected to the driving machine through a helical gear reduction. Here, the brake is mounted on the motor shaft itself and has only that torque capacity required to stop a shaft rotating at 1,200 rpm. The large brake, pawls and pawl magnets required in the Type O are thus eliminated. Driving machine on the Type R is installed vertically, as shown, to reduce space requirements.

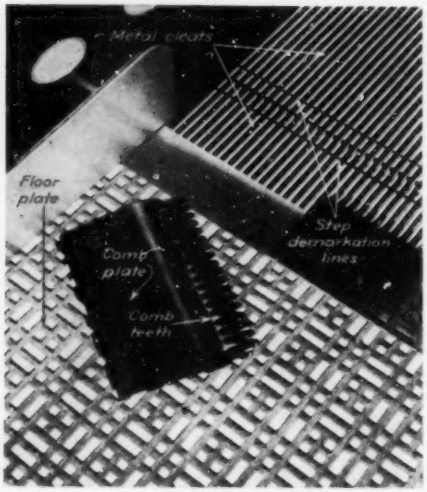


TYPE R STEP TRAILER WHEELS, connected at the apex of the step yoke, have the same diameter and construction as the rubber-rimmed chain wheels in order to standardize components. Reduction in weight of the Type R escalator is partly the result of making the step yokes as aluminum die castings rather than steel stampings. Aluminum alloys having structural properties approximating those of steel resulted in yokes that have less weight, noise, track wear, maintenance and power consumption. For a 32-in. width between balustrades, the Type R step weighs 25 lb; an equivalent Type O step would weigh 51½ lb. Rubber-rimmed chain wheels of the Type R also help reduce noise.

BOTH TYPE R AND O ESCALATORS have a pair of step chains on the sides of the step bank that transmit power by direct connection to sprockets on the main drive shaft. Step chains of both types are connected at 16-in. intervals by step axles, the length between axles being divided into three equal parts which determine the chains' pitch. On the Type O, a step axle is passed through a hollowed-out hole in an enlarged pin in every third chain roller. Each axle is supported at its ends by a 5½-in. step-axle wheel. The O-type chains for each step therefore include six large-flanged steel rollers and two large diameter step-axle wheels. In the Type R design, the step chains both transmit power and support the step load.

(*Continued on next page*)

Escalator (continued)

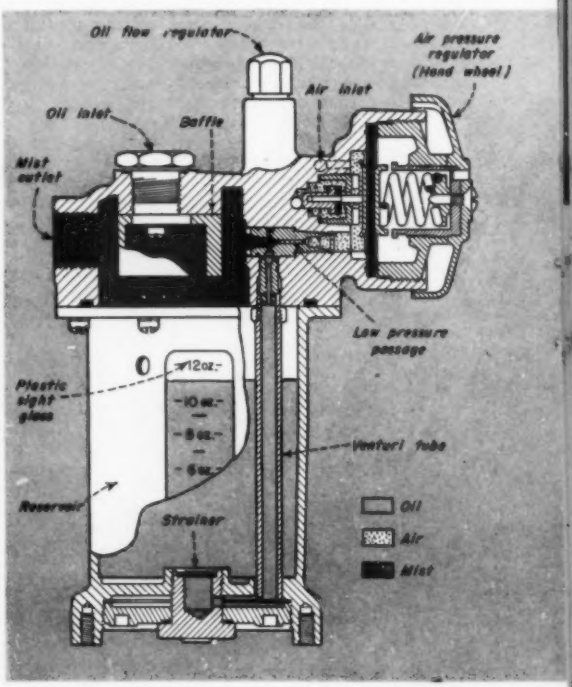


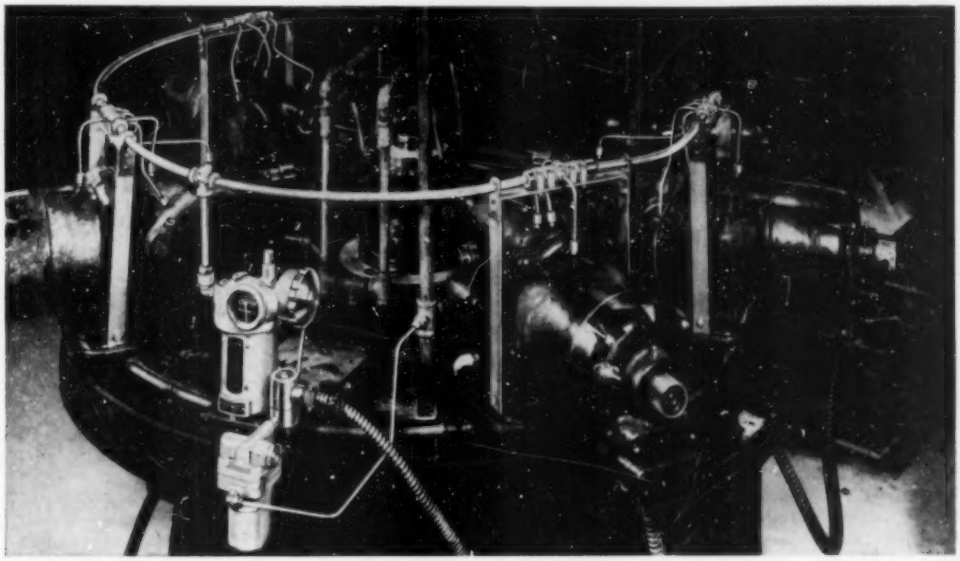
TO DISTINGUISH MORE CLEARLY between the cleats of the step treads and the comb teeth, the comb plate and teeth are made of black molded thermosetting plastic rather than aluminum. Should some object become wedged between cleats and comb teeth, the latter fracture. Installation of a new comb is simple and inexpensive. The floor plate was formerly an ornamental casting supported by welded structural parts. Strong aluminum castings have been designed to make these plates self-supporting, thus doing away with additional structural members.

A SINGLE-WRAP TRACTION HANDRAIL SYSTEM is used in the Type R escalator. The Type O requires two drive sheaves to overcome frictional resistance encountered in high rises. Stretching of the Type R handrail has been eliminated by installing a length of steel tape in each handrail. The tape permits high tensions without collapsing the handrails and eliminates the elaborate tensioning device used in the Type O. Tape joint is made by vulcanizing a lap splice of rubber film between the ends.

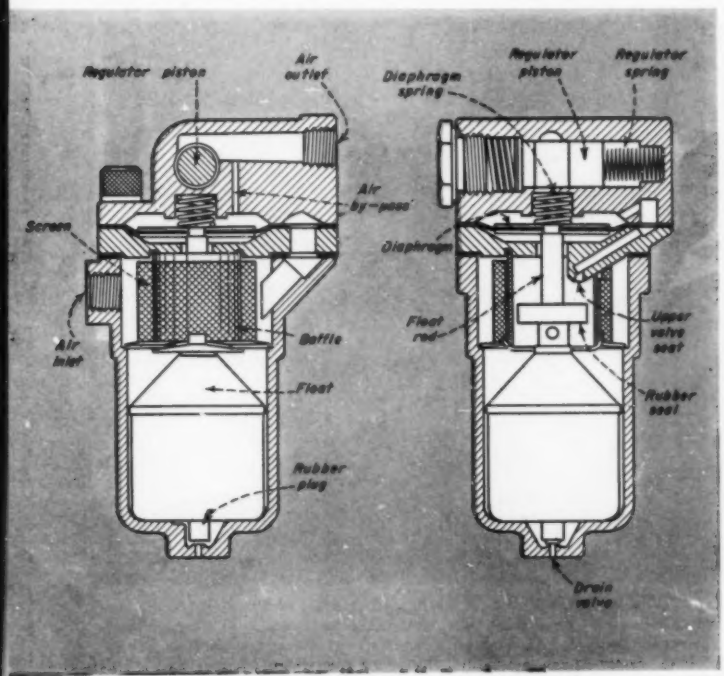
Mist Lubricator Has No Moving Parts

Continuous, automatic pressure lubrication of machines containing as many as sixty bearings or similar friction points is obtainable at low cost with Stewart Warner's new mist oiling system. A lubricator containing no moving parts atomizes oil with air from a standard shop compressor and thrusts the mixture against a baffle, causing the more minute particles to pass around the baffle and out through hydraulic tubing as a mist to points of lubrication. A solenoid valve actuated by the machine being lubricated admits air to a self-emptying water separator which both dries and cleans the air. Adjustments for both the air and oil supply make the system adaptable to different types of oil and machine bearing configurations. Economy of operation results from various factors: low cost of air compressing equipment, low oil consumption and reduced maintenance. The aerated oil also ventilates and cools each bearing in addition to maintaining a continuous film of lubricant.





FIVE TRANSFER LINES feed each of four heads on a Kingsbury Drilling Machine to lubricate bearings, gears, cams and spindles. With one cu ft per min of air at 10 psi, this unit uses about one ounce of oil per 8-hr day.

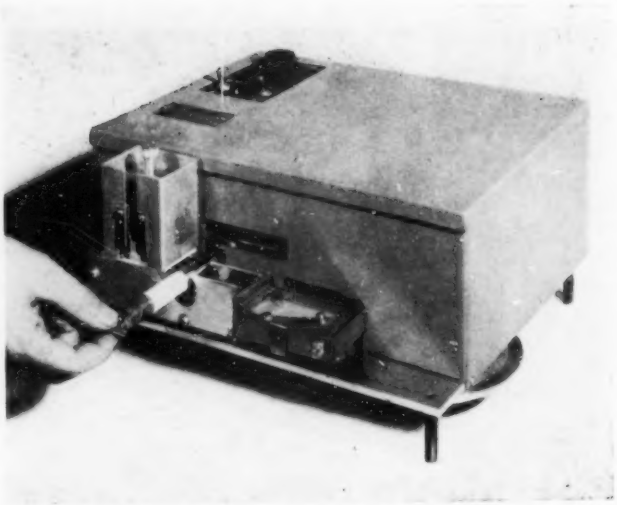


LUBRICATOR ASSEMBLY is the heart of the oiling system. Clean dry air from the water separator passes through the pressure regulator to a pressure gage (not shown) and then into the low-pressure passage. As in the well-known aspirator, the oil is sucked up the venturi tube and ejected as a spray against the baffle. The larger oil particles precipitate out when they strike the baffle and drain back into the reservoir. The smaller, lightweight particles remain in the air and are carried through feed lines to the various bearings being lubricated.

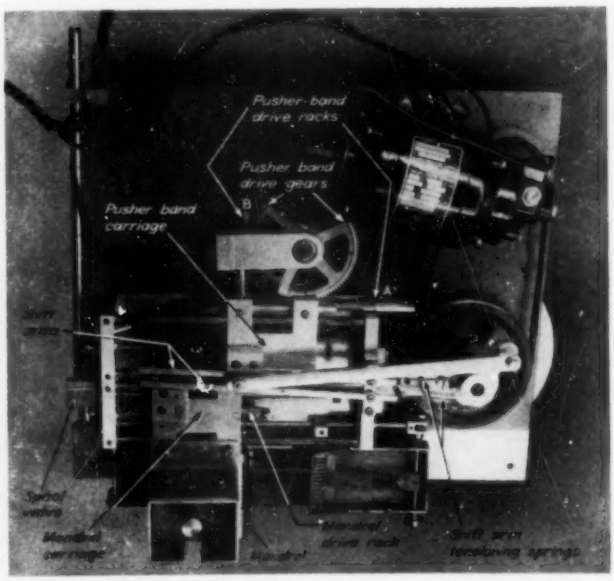
WATER SEPARATOR is self-emptying by virtue of the metal-covered float. Incoming air passes through the screen, which filters out dirt and moisture, and then up into the outlet port. Water drips down around the float, causing the latter to rise until rubber seal covers upper valve seat. After the air is sealed off, air pressures above and below diaphragm are unbalanced as air escapes through the by-pass into the outlet port. Reduced pressure above diaphragm allows float to pull rubber plug off lower valve seat, permitting water to drain out the bottom.

New Tube Labeler Has Simple Drive Linkages

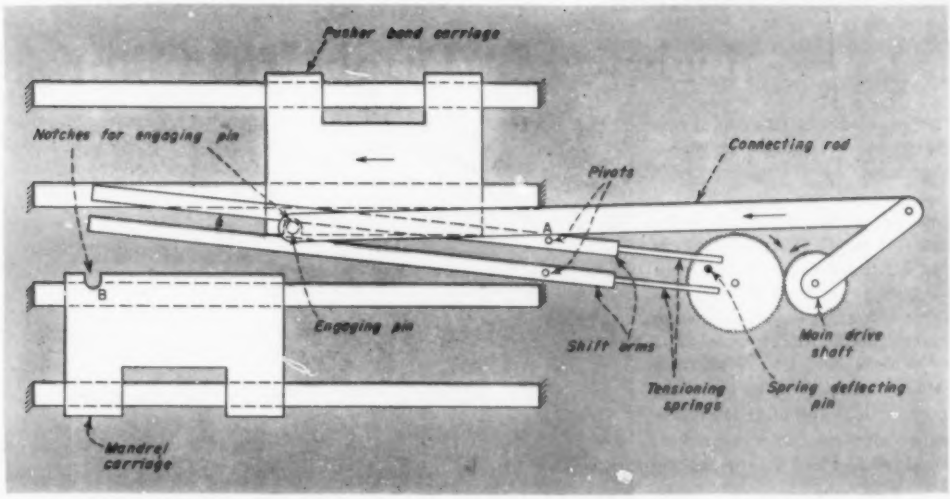
Two carriages, one for rotating a mandrel and the other for reciprocating a metal pusher band along the surface of the mandrel, are driven in sequence from a single connecting rod in a new collapsible tube labeler. Thus the two operations of rolling the label around the mandrel and pushing it off the mandrel onto the tube always occur at different times during the cycle. Switching of the drive from one carriage to the other is accomplished by an automatic escapement mechanism which pushes a drive pin at the end of the connecting rod into a notch machined in each carriage. As each carriage is oscillated on its own pair of ways, various racks, gears and control linkages are actuated in proper sequence. The mandrel carriage performs several functions, thus making it possible to reduce the number of parts and simplify the overall design. Maintenance problems are also reduced because the two carriages are made of self-lubricating Oilite material and several pivot points have sealed anti-friction bearings. Labels are pulled from the magazine by a vacuum system controlled by a spool valve and a series of holes in the wall of the hollow mandrel shaft. Electric thermostat built into the glue reservoir keeps the thermoplastic adhesive within predetermined temperature limits so that proper tackiness is maintained. Made by the Potdevin Machine Company of Brooklyn, N. Y., the labelling machine is capable of 30 label applications per minute.



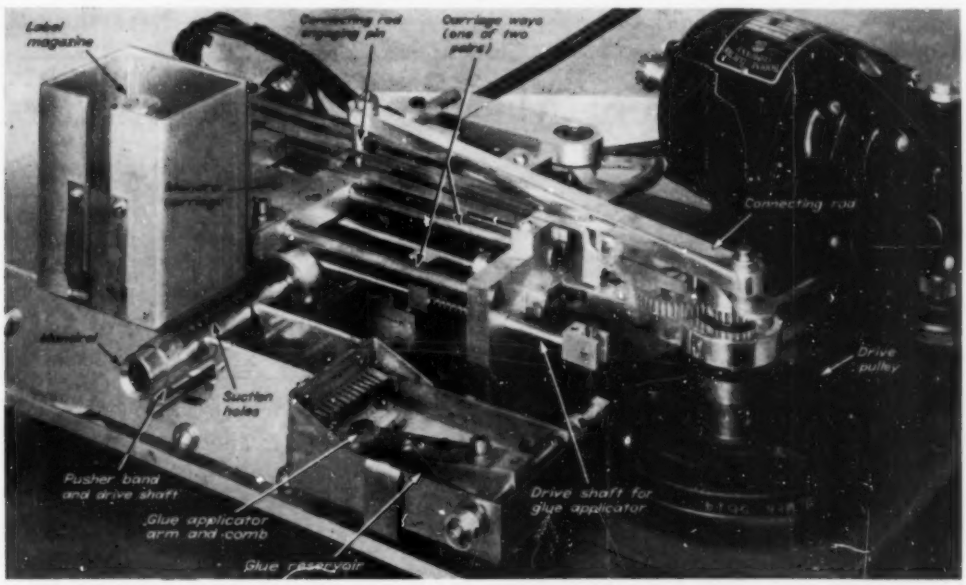
WITH COLLAPSIBLE TUBE held against end of mandrel, which is machined to fit end contours of tube, formed label is pushed off the hollow mandrel onto the tube. During the forming operation, label is held against mandrel by a vacuum, while glue is applied between the overlapping ends of label. The thermoplastic glue is stored in a reservoir that is maintained at proper temperature automatically by a thermostat.



MANDREL CARRIAGE is in disengaged position and pusher band in extended position, illustrating the point in the cycle when the formed label leaves the mandrel. As the pusher band carriage moves to the right, rack *A* rotates the upper drive gear and, through a common shaft, the lower gear. Latter drives rack *B*, an extension of the shaft carrying the pusher band.



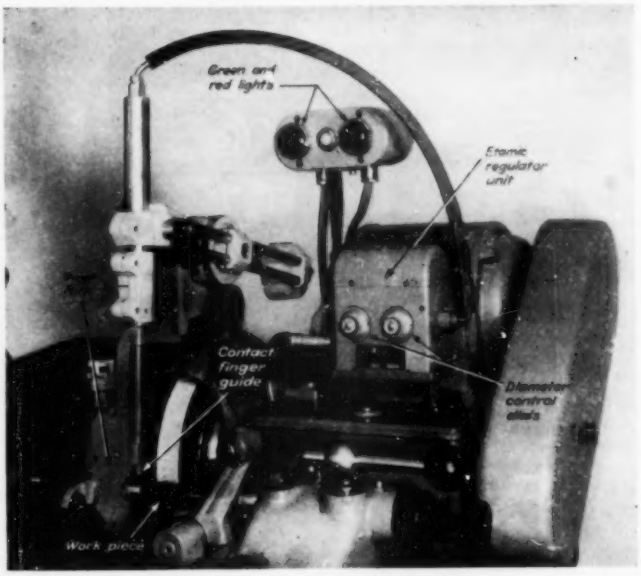
SWITCHING MECHANISM for engaging the pin at left end of connecting rod, first in mandrel-carriage notch and then in notch at corner of pusher band carriage (as shown), consists of two shift arms and a pair of spur gears which are driven from main drive shaft. Position of the spring-deflecting pin in large gear is such that, when it contacts the tensioning spring attached to upper shift arm, this arm will pivot at *A* and force engaging pin at left end of connecting rod into mandrel carriage notch *B*. Seating of the pin in this notch take place when the pusher band carriage reaches the left end position of its travel where the pin and the notch *B* are in alignment.



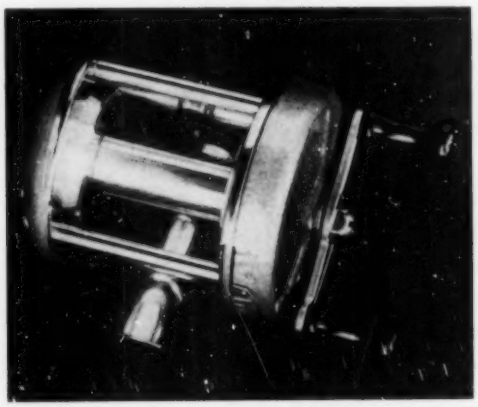
DURING THE FIRST HALF of the cycle, the connecting rod pin pulls the mandrel carriage to the right. Movement of this carriage performs three functions: Turns the mandrel by means of a rack and gear (not shown), opens the spool valve to evacuate the hollow mandrel shaft and pushes the spring-loaded drive shaft for the glue-applicator mechanism. The applicator arm and comb oscillate up and down in the reservoir. Each time the arm rises, the teeth of the comb leave dabs of glue on the underside of a label so that when the mandrel brings the ends together, they adhere.

Lightweight Diaphragm Controls

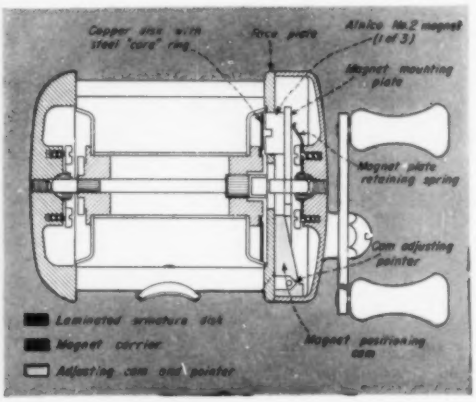
Low-inertia diaphragms, which control the operation of the Etamic air micrometer, have a sensitivity of about 0.1 micron. Applied to a grinding machine head, this device makes it possible to automatically true shafting diameters to close tolerances. Shop air at 60 to 100 psi is directed through tubing and orifices so that pressure differentials across the two diaphragms close electrical circuits containing signal lights and controls for the grinding head. Jaw-shaped gage fork carries two carbide indexing tips which bear against the work piece and a contact finger, which regulates the discharge of air through an annular orifice around its periphery. Dials set pressures, at which differentials develop across the diaphragms. Manufacturer is Ateliers de Normandie, 12 Bis Place de Laborde, Paris 8, France.



Permanent Magnets Control Braking

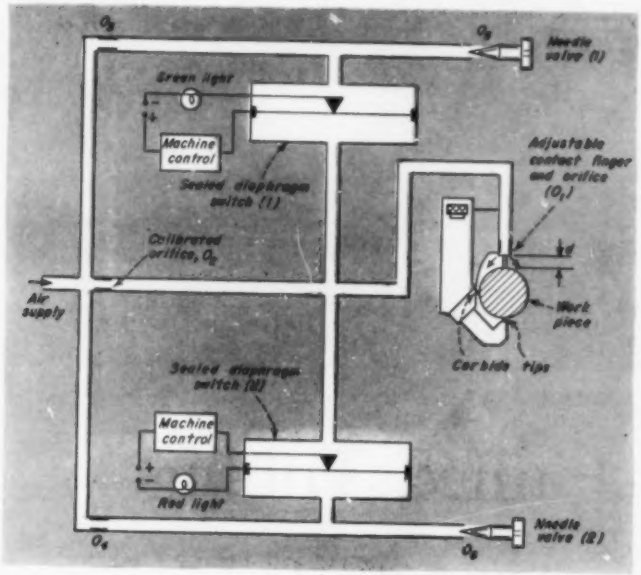


THREE SMALL Alnico magnets are mounted inside one end cap of the Electromatic fishing reel so that a copper disk attached to the adjacent spool flange rotates in their magnetic field. The spool is therefore braked during the first few seconds of a cast, thus retarding movement of the spool and preventing the line from kinking.



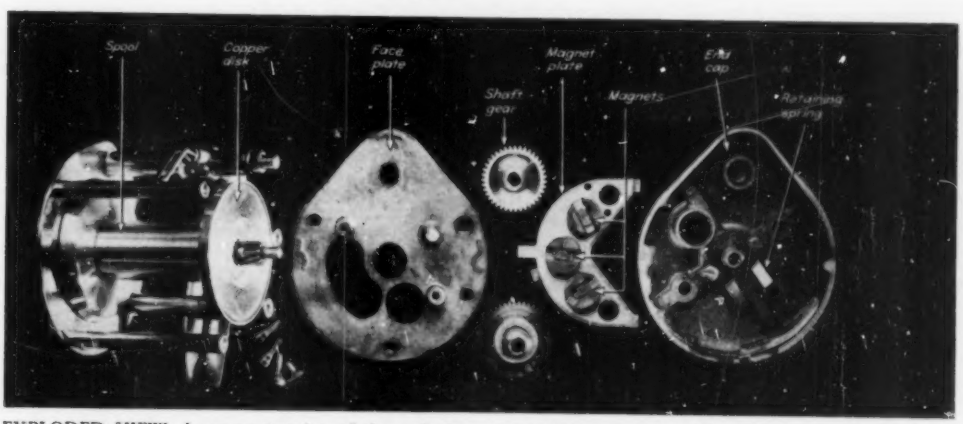
BRAKING EFFECT is varied to suit casting conditions by moving the magnets in relation to the disk. Magnets and disk are separated by moving the pointer, which wedges the tapered cam between face plate and magnet plate. Retaining spring forces the magnet plate toward the copper disk when the cam is retracted.

Sensitivity of Air Micrometer



TWO PARALLEL differential-type air systems are within the Etamic regulator unit. Center or "measuring" line is common to both systems, each of which has a separate "regulating" line. Orifices O_2, O_3 and O_4 are calibrated for each unit. Orifice O_1 is adjusted for given "rough" (d_1) and "finish" (d_2) diameters as balanced at orifices O_5 and O_6, which are regulated by needle valves (1) and (2). With d_1 corresponding to a diameter slightly oversize of final dimensions and d_2 representing the final diameter, green light stays "on" until work piece is ground to d_2 dimension. This light then goes "out" because upper diaphragm is deflected, thereby breaking the associated electrical circuit. Shaft truing operation then takes place. When d_2 dimension is obtained, lower diaphragm closes circuit to red light, and actuates the control that retracts the grinding head and stops the machine. Jet action of the air escaping at O_1, assists in cooling and cleaning the ground surface of the work piece so that the airflow pattern is "true" at the critical dimensions.

# of Spool in Fishing Reel



EXPLODED VIEW shows construction of the reel, the parts made of aluminum and the copper disk on the end of the spool. Both the magnet mounting plate and face plate must be made of nonmagnetic material in order that the electrical brake function properly. Aluminum was selected to keep the weight low and because of its corrosion-resistant properties. Other aluminum parts include the shaft gear, spool and the end caps. The latter and the face plate are die cast. Some of the attachments are made by driving self-tapping screws directly into cored holes in these castings. The Horton Bristol Company of Bristol, Connecticut manufactures the Electromatic reel.

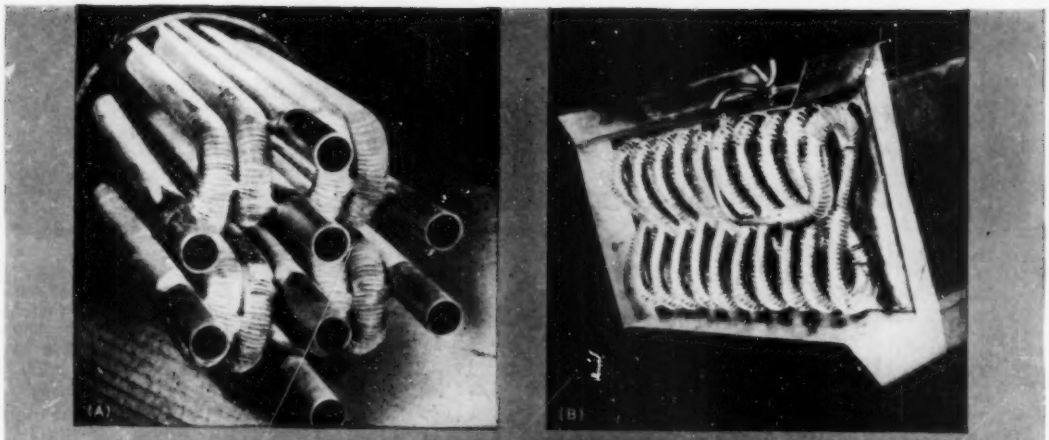


Fig. 1—How finned tubing is used in heat transfer equipment: (A) Condenser for air conditioning unit with integral finned tubing formed into oval-type coils. Bends are on 1¼ in. tube centers. (B) Evaporator coil of "figure 4" design for experimental air conditioning unit. Tubing is ⅜ in. ID., 9 fins per in., copper, with integral fin con-

Integral Finned Tubing For Heat Exchangers

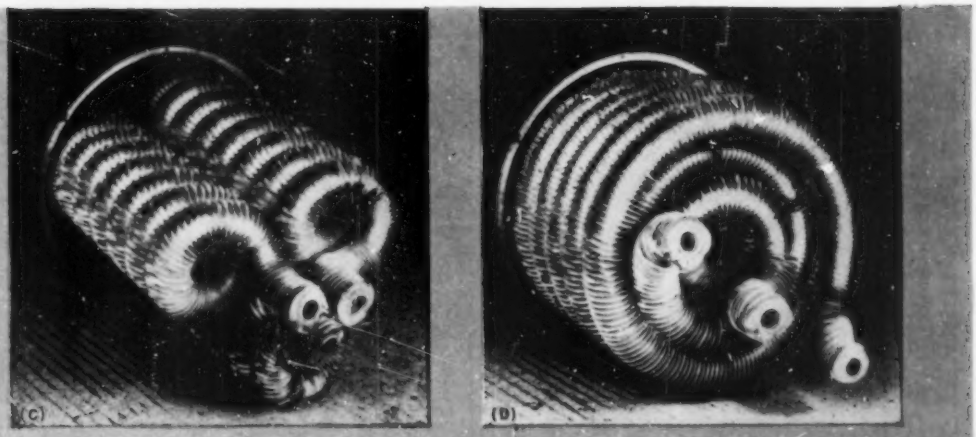
The greater heat exchange capacity and flexibility of integral finned tubing results in small condensers and exchangers for refrigerators, torque converters, fluid magnetic brakes, unit heaters, and industrial equipment—and consequently, the conservation of critical materials. The trend is toward unitized and sealed construction to facilitate application.

WALTER P. HILL
Manager, Product Development, Wolverine Tube Division
Calumet and Hecla Consolidated Copper Company

INTEGRAL FINNED TUBES may be used to advantage in heat transfer applications whenever the film coefficient of heat transfer on the outside of a tube is less than that on the inside. Smooth or plain tubing is adequate in cases where the inside and outside heat transfer mediums have nearly equal film coefficients. For other combinations, however, the required surface area difference cannot be obtained with practical tube diameters and wall thicknesses. Increased surface area is particularly desirable for liquid-to-air combinations. Thus, in many hot-water air heaters, oil and chemical coolers, and refrigeration coils, Fig. 1, finned tubing offers a substantial increase in surface area and is lighter and more compact than plain tubing.

In the past, the use of fins to increase surface area has been limited by fabrication, strength and corrosion difficulties. Crimped and soldered fins sometimes corroded at the base, were structurally weak, and gave imperfect heat flow. Fins machined in thick-walled tubing were expensive.

An entirely different production method, known as rotary extrusion, has been developed by the Wolverine Tube Division of Calumet and Hecla Consolidated Copper Company. The result of this cold roll-forming process is a finned tube having integral helical fins. It is manufactured in solid copper, copper-base alloys, solid aluminum, steel, and bi-metal (integral finned tube with liners of other metals). In the case of bi-metal, two tubes, one inserted in the other, are fed through the center of three sets of rotary dies, Fig. 2. Either the end of the tubing must be tapered, or the dies opened and then shut on the tubing to obtain a proper finning start. After this, the dies feed the tubing through the machine at a rate depending upon the pitch diameter and ro-



struction. (C) Experimental water-cooled condenser. Coils of high fin construction formed over 15/16 in. dia arbor. (D) Experimental water-cooled condenser. Coils closely packed for insertion in 6 in. dia. steel shell. Finned tubing is formed of copper, copper alloys, aluminum, or steel; or of one of these metals with liners of other metals.

tational speed of the dies. On tubes having 19 fins per in., the production rate would be between 10 and 12 fpm; on tubing with five fins per in., the rate would be closer to 15 and 25 feet per minute.

In bi-metal, as the fins are produced on the tubing, only the metal in the outer tube is extruded. A mechanical bond is formed between the inside tube or liner and the outer finned tube. Since the fins are part of the tube itself, there are no cracks or crevices in which electrolytic corrosion can occur.

The outer tube is extruded from aluminum, not only because of its good thermal properties, but being an unalloyed metal, it is inexpensive, has good corrosion resistant properties, and can be easily cold-worked. Seamless tube of copper, copper base alloys or steel and its alloys is used as the liner. The liner metal is selected primarily on the basis of corrosion resistance to the fluid medium with which it is to come in contact. The effect of different metal on the coefficient of heat transfer, Fig. 3, may also affect the choice of liner material specified.

By the nature of the rotary extrusion process, tubes having more widely spaced fins can be made in larger diameters. Naturally, the accumulation of dust, lint or other foreign matter on fins of large diameter tubes (higher fin height) decreases the efficiency of the fins. Tubes with 19 fins per in. are affected less by outside fouling of condensible gases and are less critical in fin surface circulation. Tubes with high fins are best used with high outside air velocities. As with plain tubing, efficiency, Fig. 4, increases with closer center spacing of the tubes and increased flow exposure.

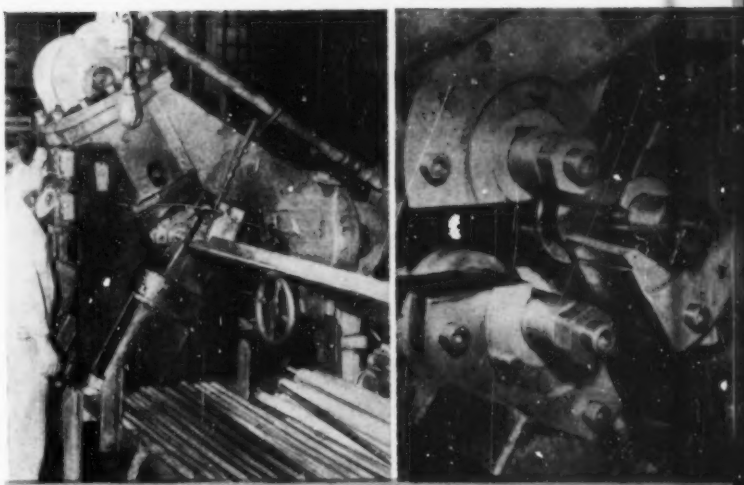


Fig. 3—Equipment and dies (right) for rotary extrusion of finned tubing. As the dies rotate, metal is extruded between the die spacings. Production rate depends on pitch diameter of fins and rotational speed of dies, see text.

Integral finned tubes are useful with low heat transfer rates (15 to 20 Btu/hr/ft²F), especially in liquid-gas heat transfer applications. The relative advantages are, of course, somewhat less at the high rates found in some condensers (1000 Btu/hr/ft²F), or for most gas-to-gas and liquid-to-liquid heat exchange processes.

In vapor condensers and air heaters, heat is exchanged between one fluid inside the tubes and a second outside the tubes. The tubes carry the fluid with the larger film coefficient of transfer; the fluid which is more reluctant to take on or give up heat is exposed outside the tubes to the greater sur-

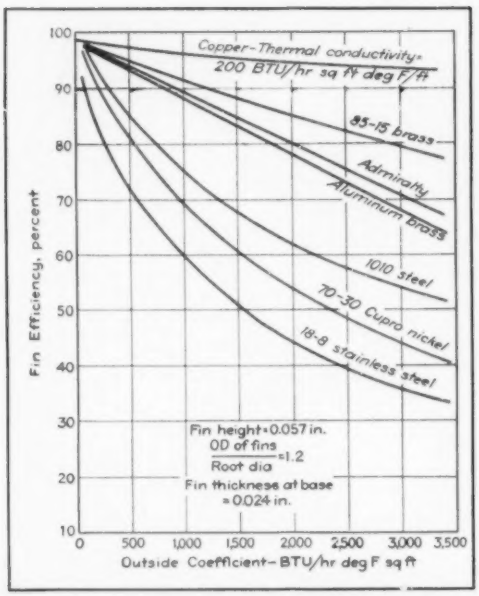


Fig. 3—Effect of liner material on fin efficiency. Decline in efficiency with a high rate of heat transfer decreases advantages of finned tubing. Aluminum usually is fin material.

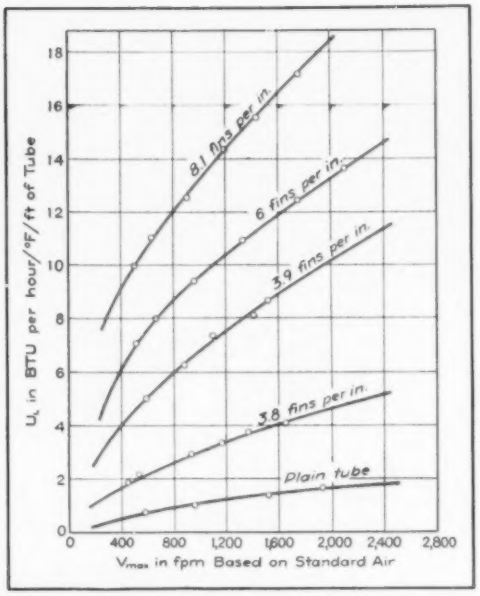

8.1 fins per in.
6 fins per in.
3.9 fins per in.
3.8 fins per in.
plain tube
U_L in BTU per hour/°F/ft of Tube
V_max in fpm Based on Standard Air

Fig. 4—The effect of fin height and outside fluid velocity on U_L, the coefficient of transfer. Increase in surface of finned tubing does not cause proportionate increase in U_L due to shielding.

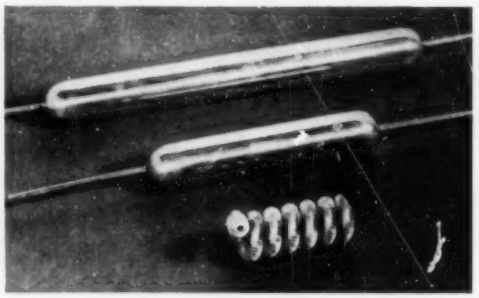


Fig. 5—Experimental heat exchangers. Helical coil of ¾ in. I.D., 9 fins per in., is fabricated for insertion in 3 in O.D. shell.

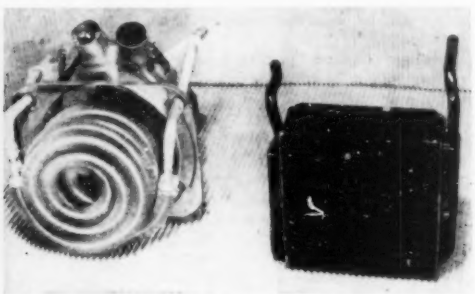


Fig. 6—Experimental bus heater. Coil of 5/16 in. I.D., 9 fins per in., integral aluminum finned tube. Old heater is at right.

face area. Maximum efficiency is obtained with inside and outside surface areas inversely proportional to film coefficients.

The transfer equation at a surface is

$$q = UA\Delta T, \text{ or} \quad (1)$$

$$q = \frac{\Delta T}{UA} = \frac{\text{Driving Force}}{\text{Resistance}} \quad (2)$$

where q is the transfer rate; A is the area normal to heat flow; ΔT is the temperature difference; and U is the coefficient of transfer.

Heat resistances are additive. Neglecting the resistance of the tube metal, the total resistance to flow from gas (1) to gas (2) is

$$R = \frac{1}{U_1 A_1} + \frac{1}{U_2 n A_1}$$

where $n A_1 = A_2$

The condition of maximum efficiency, found by equating the differential of R with respect to n to zero, is:

$$-\frac{U_1}{U_2} = m = \frac{A_2}{A_1}$$

Since the direction of tube-fluid transfer makes U_2 and U_1 opposite in sign, the exposed areas are inversely proportional to film coefficients. While the above equation is theoretically correct, under actual operating conditions, the outside area or fin efficiency probably will not be 100 percent.

Standard sizes and large scale production are additional advantages in the production and application of integral finned tube.

After forming, integral finned tubes are often coiled or bent, Fig. 5, and inserted in shells to produce small, lightweight heat exchangers. The tapered fin construction of integral finned tubing permits ease in bending or coiling for application in a wide range of products. Such exchangers have been used successfully in air coolers for processing and refining, machine tool oil coolers, refrigeration equipment, unit heaters, coolers for gas and oil pumps, and for similar applications.

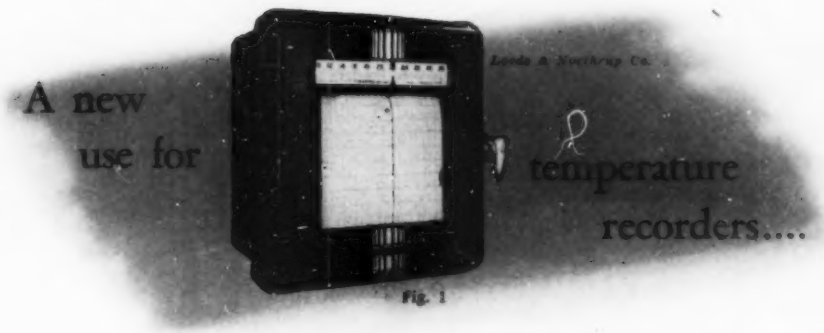


Fig. 1

Ready-Made Amplifiers For Transducer Signals

Already available to machine designers are transducers that will respond to almost any physical, electrical or chemical quantity. But most transducers require amplifiers, which usually involve a full-scale engineering project if designed from scratch. Many times a better—and cheaper—control system results when improvisation is substituted for original amplifier design.

T. R. BREUNICH
Project Engineer
Sonntag Scientific Corp.

In an increasing number of applications, transducers are used to supply intelligence to the automatic control systems of machines or processes. For example, a resistance strain gage may supply the signal to shut down the pump of a hydraulic press when the allowable pressure limit has been reached. Or, a variable inductance coil could be made to sense the rate of acceleration of an airplane and pass-regulating signals to the fuel metering apparatus.

In almost every case, the designer of these control systems has the problem of boosting the small electrical signal from the transducer to a magnitude sufficient to operate a switch, relay, servo motor or other such device. Clearly, the engineering of an appropriate amplifier is a major project—and a very expensive one, unless the quantities involved are high. But, perhaps there is a simple solution to the amplifier problem. In many cases, a suitable signal amplifier can be found right inside the case of the long-available and well-proven temperature recorder or controller. After simple modifications, a temperature controller serves as an efficient amplifier for transducers.

Normally, the product engineer would consider temperature controllers as being foreign to the field of machine design. This is logically so, because temperature controllers are engineered specifically for the chemical, steam generating and similar industries. They are regarded as "specialized" instruments. Actually, the only special feature of temperature controllers is their ability to respond accurately to small currents or voltages. While the latter are typical of the outputs of thermocouples and resistance bulbs, they are also typical of the whole field of transducers or sensing devices.

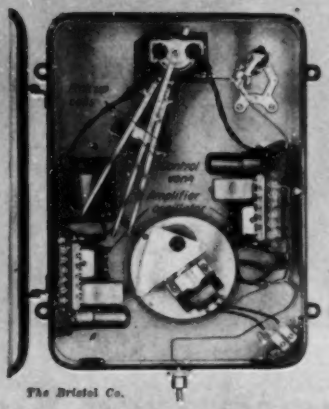
As a group, temperature controllers have had a long period of development, field testing and redesign to insure ruggedness, dependability, long life and accuracy. They have been developed to withstand rough treatment and poor environmental conditions without loss of accuracy or performance. This fact makes temperature controllers adaptable to most machine control problems from a mechanical point of view. And their high signal sensitivity makes them adaptable to most control circuits from an electrical point of view.

The incorporation of these units in a control circuit has advantages other than those noted above. Temperature controllers are mass produced instruments. Parts are interchangeable and inexpensive and many components consist of plug-in type units for quick field repair. In addition, the manufacturers of the controllers have established complete nation wide service organizations to service and repair them in the field. This relieves the machine designer and manufacturer of the problem of providing specialized field service to repair amplifiers of original design.

Construction Details of Temperature Controllers

There are two basic types of temperature control and recording instruments available. In one, the minute signal is fed to a galvanometer. In the other, the signal is admitted di-

Fig. 2—View of interior of free-vane temperature recorder. The shaft carrying the vane is actuated by an aneroid-type pressure detector.



The Bristol Co.

Fig. 2

Fig. 3—Schematic of temperature recorder mechanism. The direction of rotation of the followup motor is controlled by the position of the aluminum vane in the oscillator pickup coils.

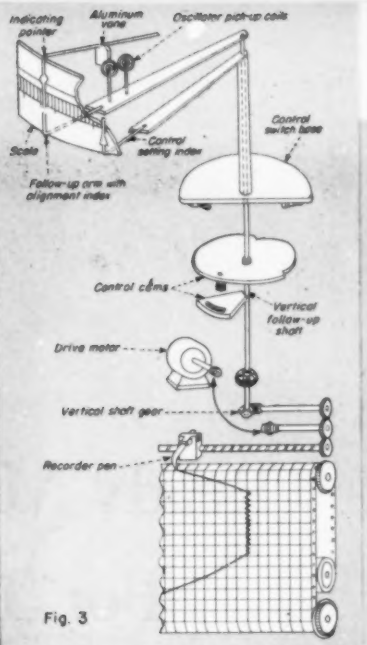


Fig. 3

Wheelco Instruments Co.

rectly to the electronic amplifying and followup circuits. Both of these types take on various mechanical forms and accomplish the end results by different followup methods, but the basic principles are the same.

Instruments using galvanometers are either the full deflection type, where the pointer is free to travel full scale, or the potentiometer type. In the latter, the galvanometer is incorporated in either a Wheatstone bridge or a potentiometer circuit. The galvanometer deflects when the incoming signal unbalances the bridge or the potentiometer, whereupon, a followup mechanism acts to correct the unbalance.

Shown in Fig. 1 is a potentiometer type recorder. The full deflection type is similar in external appearance. The lower dial pointer indicates the temperature at any instant, while the upper pointer is set at the precise temperature at which a control action is desired. When the upper and lower pointers coincide, the control contacts close or open, depending on the external circuit being used.

These instruments are available both as multipoint controllers (i.e., they will close or open a series of control contacts at various temperature settings) and as combination controller-chart recorders. Large circular dials are also supplied for distant readings. Temperature controllers can be operated on signal voltages from as low as 10 millivolts up to voltages of 110 or 220 volts. The usual signal source is direct current but they can be easily adapted for alternating current and the signal limits noted above can be widened if necessary. The control contacts will handle three to 6 amp noninductive a-c loads, which is usually adequate for external control circuits.

The main feature of these instruments—the one that makes them rugged and dependable—is the method used to get positive control action without sacrificing galvanometer sensitivity. In all cases, the galvanometer is used only to indicate while the control function is handled by a powerful followup system.

In the full scale deflection types the coupling between indication and control is electronic. The sensitive galvanometer pointer carries a small aluminum vane or flag which moves between two flat spiral wound coils. The electronic system is designed so that when the vane is between the coils the circuit oscillates, when out, ocillation ceases. The actual control movement where this takes place ranges between 0.002 and 0.003 in., so for practical purposes it is a sharp, well defined point. The a-c wave, generated by the oscillating circuit, is amplified electronically to a high power level. When the instrument is a controller only, the amplified voltage actuates a relay at the control temperature. If the instrument is a recorder, the amplified wave is used to control a followup (tracing) circuit.

The mechanical arrangement of one such instrument is shown in Fig. 2, which is a two position or two control point device. This particular unit uses an aneroid mechanism, which is operated by gas pressure from a temperature bulb, instead of a galvanometer. But in all other points it is similar to a galvanometer actuated unit. As the pointer moves, the vane attached to it enters one or the other of the control coils and triggers the oscillator circuit which in turn operates a relay. The control coils may be moved so the control point occurs where desired.

When multiple control and recording is required, the circuit is modified so that the coils control a followup motor system instead of the relays. This system is shown schematically in

Fig. 5—Sequence of operation of mechanical arrangement for detecting galvanometer deflection. In the first picture, the electrical system is in balance, as shown by undeflected galvanometer pointer. Setting levers are open. In the next picture, the setting levers have closed, finding the undeflected pointer at zero. Balancing mechanism does not move. Then, temperature has changed, as shown by deflected pointer. The system is unbalanced. Setting levers, again open, are about to close once more. The last picture shows that the setting levers have closed, this time on the deflected pointer. In moving to an off-center position, they have tilted the clutch arm. The latter now clamps to the clutch disk. Cam at right is about to return arm to horizontal position. This will turn the disk and with it a slidewire to rebalance the system.

Leeds & Northrup Co.

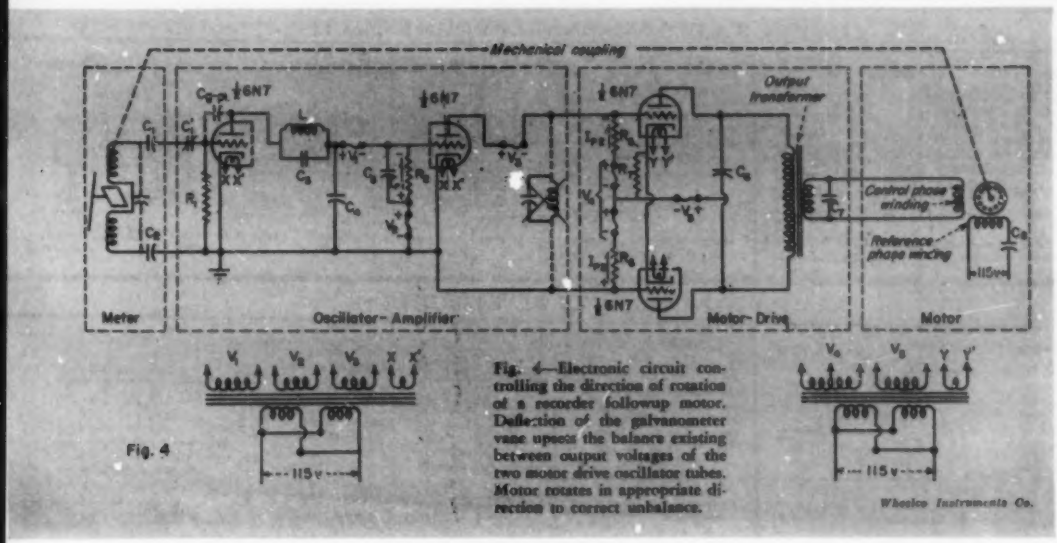


Fig. 4

Fig. 4—Electronic circuit controlling the direction of rotation of a recorder followup motor. Deflection of the galvanometer vane upsets the balance existing between output voltages of the two motor drive oscillator tubes. Motor rotates in appropriate direction to correct unbalance.

Fig. 3, while the electronic circuit is shown in Fig. 4. In this system, the direction of rotation of the followup motor is controlled by the position of the aluminum vane in the oscillator pickup coils. When its edge is at the center of the coils the oscillator-amplifier output, Fig. 4, balances the motor drive circuit so that no motor rotation occurs. Either side of this point changes the oscillator amplifier output so as to give a phase shift in the motor winding and result in rotation of the drive motor.

The position of the vane in the control coils determines the output voltage of the oscillator circuit. This voltage is then amplified for use on the motor drive circuit. As noted on the diagram a dual purpose tube is used, one section being used for the oscillator and the other for amplification.

This voltage is used to bias the two sections of the motor drive tube. At low voltage values one section conducts, at high values the other section conducts and at an intermediate value they balance each other.

This means that as the edge of the vane enters the coil, one section is conducting. As the edge reaches the center of the coil the two sections balance and as it passes beyond the center, the other section takes over.

When one section is conducting, the drive motor rotates in one direction but when the other conducts, the voltage in the control phase winding is reversed and the motor reverses. At the null point no voltage is generated and the motor armature remains stationary.

Referring again to Fig. 3, the drive motor is geared to the followup arm, control cams and the recorder pen. It is so phased that the followup arm closely follows the indicating pointer to keep the coils and vane in the same relative position, or to keep the system in the nulled condition.

In effect, the followup arm is joined to the indicating pointer through an electronic linkage. At the same time, the control cams and the pen follow in synchronism.

The control switches on this system

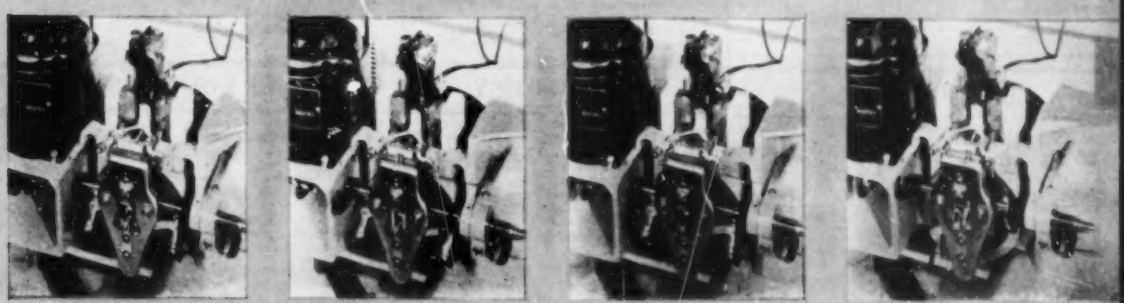
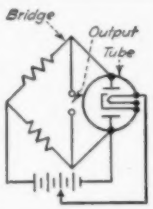


Table 1—Transducer Circuits for Control Applications

ACCELERATION-SENSITIVE CIRCUITS

Vacuum Tube

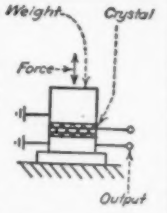


Special vacuum tube has two plates flexibly mounted that deflect under acceleration forces. Current in bridge varies directly as acceleration of tube.

Range {0-200 cps. / 1-50 g's.

Preamplifier needed below 10 g's.
Above 10 g's, output signal is about 0.010 volt.

Piezo-Electric Crystals

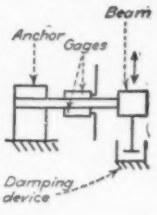


Inertia force of the weight varies the output of the crystal. Output is proportional to inertia force or acceleration.

Range {3-4,000 cps. / 0.1-600 g's.

Output signal varies from 8 to 35 millivolts per g.

Strain Gages



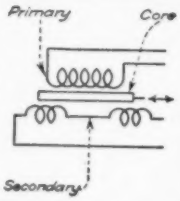
Inertia forces acting transverse to beam causes beam to bend. Gages are connected in a bridge circuit and signal is proportional to inertia loading or acceleration acting on beam.

Range {0-2,000 cps. / 0-200 g's.

Signal is 0.3 to 7.5 millivolts, per g.

MOTION-SENSITIVE CIRCUITS

Differential Transformer

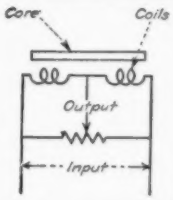


Movement of core gives a secondary voltage proportional to displacement.

Range: 0±2½ in.

Output signal is 0-3 volts a-c.

Variable Inductance

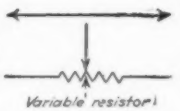


Movement of core varies coil induction in proportion to displacement. Output voltage also proportional to core displacement.

Range: 0±½ in.

Output signal is 0-0.2 volts a-c.

Variable Resistance



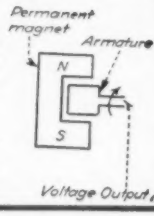
Lineal or rotary motion slide resistor and contact gives a resistance either directly proportional to or a function of the motion.

Range depends on linkage ratio.

Signal depends on impressed voltage.

SPEED-SENSITIVE

Generator



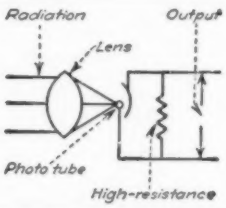
Armature rotates in field of permanent magnet giving a voltage output directly proportional to speed.

Range: 0-22,000 rpm.

Output signal is 0-300 volts d-c; 0-150 volts a-c.

RADIATION CIRCUITS

The following devices are used for spectrometer analysis, using prisms to give monochromatic light. They can also be used to measure turbidity of smoke or liquids by aiming a light source thru the medium to be checked.



Photocell

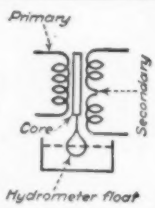
Radiation focused on plate of photocell. Change of current is detected by high resistance and changed to voltage signal.

Ultra-violet and visible range.

Signal: Some applications give 100 microamps. Others very low level and require a preamplifier.

DENSITY

Differential Transformer



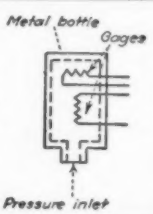
Hydrometer float position depends on density of fluid. Position of core on float determines output of transformer.

Range: All densities suitable for hydrometer type measurement.

Output signal is 0-0.05 volts a-c.

PRESSURE-SENSITIVE CIRCUITS

Resistance Strain Gage

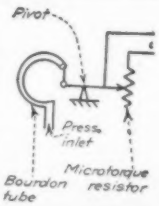


Gages on metal bottle measure expansion of walls under pressure and give a change of resistance proportional to the pressure.

Range: 0-50,000 lb.

Output signal is 0-0.010 volts a-c.

Variable Resistance



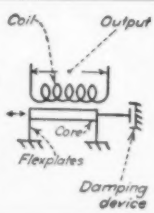
Bourdon tube operates low torque resistor (0.01 in.-oz. torque) for a change of resistance with pressure change.

Range: 0-6,000 psi.

Output signal can be made as large as desired, depending on power input.

VIBRATION

Coil and Magnet



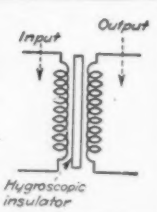
Core is suspended on flexplates and is free to vibrate without friction in axis of motion. Amplitude of movement and frequency determine voltage generated in coil.

Range: 5-1,000 cps. 0-0.6 in. amplitude.

Signal is 65 to 110 millivolts per in./sec.

HUMIDITY

Variable Dielectric



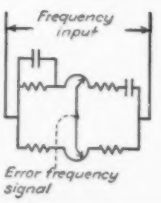
Shield between the two windings is hygroscopic and varies its resistance with the relative humidity. Output voltage varies directly as the humidity.

5-95% relative humidity.

Output signal is 0-0.010 volts d-c.

FREQUENCY

Tuned Wheatstone Bridge



The wheatstone bridge is tuned for one frequency and has no output at that frequency. Any shift causes an unbalance and an error signal.

Usually designed for frequency wanted.

Output signal range is 0-0.010 volts a-c.

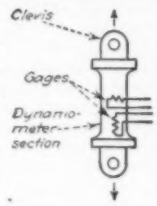
FORCE OR WEIGHT-SENSITIVE CIRCUITS

Strain Gage

Resistance gages on solid column indicate change of length or metal strain under load. Change of resistance is proportional to load applied.

Range: 0-50,000 lb.

Output signal is 0-0.010 volts a-c.

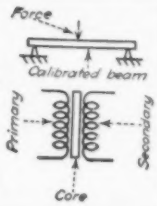


Differential Transformer

Deflection of beam under load moves core and varies transformer output in proportion to load.

Range: 0-20,000 lb.

Output signal is 0-1.5 volts a-c.



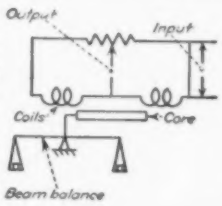
Variable Inductance

Motion of beam balance shifts core and gives voltage reading that is proportional to displacement of balance. Output represents weight unbalance of system.

Load range dependent on balance.

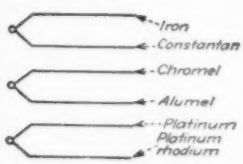
Motion limits; 0±2½ in.

Output signal is 0-0.2 volts a-c.



TEMPERATURE CIRCUITS

Thermocouple



Two dissimiliar metals generate an emf proportional to temperature difference of their two ends.

0-2,000 F.
Signal output 0-0.064 volts d-c.

0-2,600 F.
Signal output 0-0.056 volts d-c.

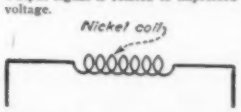
0-3,000 F.
Signal output is 0-0.020 volts d-c.

Resistance Element

Resistance of coil varies with temperature.

Range: 0-1,000 F.

Output signal is related to impressed voltage.

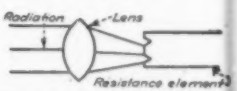


Thermopile

Lens focuses radiation of remote body on series of thermocouples.

Range: 0-5,000 F.

Output signal is multiple of signal from single couple.



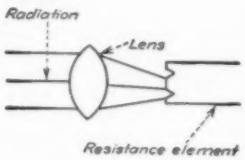
RADIATION CIRCUITS

Bolometer (resistance element)

Radiation focused on bolometer causes a resistance change that is proportional to intensity. Radiation may be monochromatic for spectrum analysis.

Infra-red range.

Output signal depends on impressed voltage.



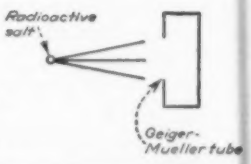
Geiger-Mueller Tube

Gamma radiation from radioactive salt actuates tube. Output proportional to distance.

X-ray range.

Output signal is low level, requires a preamplifier.

In crystallography studies, this circuit is also used for crystal analysis by means of x-rays.



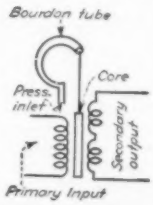
PRESSURE-SENSITIVE CIRCUITS

Differential Transformer

Bourdon tube moves core in differential transformer to give a variable secondary output.

Range: 0-6,000 psi.

Signal output is 0-3.0 volts a-c.

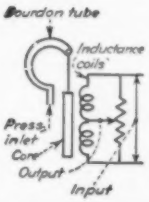


Variable Inductance

Movement of bourdon tube varies the inductance of the coils and so the balance of the bridge. This gives a voltage proportional to pressure.

Range: 0-6,000 psi.

Output signal is 0-0.03 volts a-c. (Direct current can be obtained by simple circuit change).

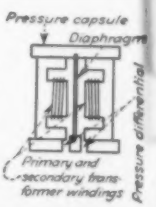


Differential Transformer

Movement of diaphram under differential pressure varies transformer coupling and gives output proportional to pressure differential.

Range: 0-50 psi.

Output signal is 0.10 volts a-c.



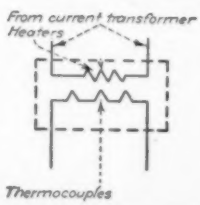
CURRENT-SENSITIVE CIRCUIT

Thermal Converter

Current from current transformer raises heater temperature in proportion to its magnitude. Thermocouples measure this temperature and their output is proportional to current flowing in main circuit.

Range: Limited only by capacity of current transformer.

Output signal range is 0-0.010 volts d-c.



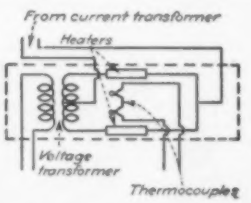
POWER-SENSITIVE CIRCUIT

Thermal Converter

Voltage of potential transformer combined with current from the current transformer raises heaters to temperature proportional to power flowing in line. Thermocouple output is directly proportional to power in circuit.

Range: Limited only by current & potential transformer capacity.

Output signal range is 0-0.010 volts d-c.



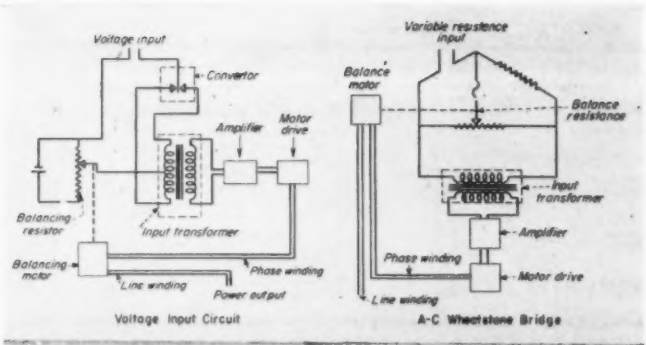


Fig. 6—Circuits for all-electronic recorders. Circuit at left is for applications where the transducer signal is a varying voltage. The bridge circuit, at right, is for transducers with varying resistance.

are mounted on the switch base, which can be adjusted but does not move with the followup system. The index pointer shows the temperature setting at which the switches will initiate control action. The important feature of this mechanism is that the galvanometer is free and all control action is by means of a comparatively powerful motor.

Mechanical Detector

The other type of deflection instrument uses the galvanometer as a null detector and as a mechanical actuator for the followup system. This instrument is designed in such a fashion that, while measuring, the galvanometer is free, but during the followup period it is locked. This gives the desired high sensitivity for measurement and the necessary force for control action. The control movement on this type is intermittent, but the rate of response is the same or faster than the full deflection types.

The actual mechanism consists of a sensitive galvanometer, a pointer lock, sensing fingers, a clutch, power cams and a driving motor. During the measuring cycle, the galvanometer is free and moves in proportion to the unbalance of the potentiometer circuit. During the control cycle, the pointer is locked and the position sensing fingers contact the pointer. If the unit is balanced no control action takes place. But if an unbalance exists, the clutch is displaced relative to the control cams, which act to rebalance the system as shown in Fig. 5. This mechanical rotation of the clutch is used to operate the potentiometer slide-wire resistor, to move the pointer or recording pen and operate the control switches.

All of these potentiometer units have standardizing circuits in which the voltage of the circuit battery is balanced against that of a standard cell. On some instruments this operation is manual while on others it is fully automatic, the voltages being compared and adjusted every 20 to 30 minutes. The galvanometer on this type instrument is very sensitive. Because of the potentiometer circuit, no power is drawn from the transducer most of the time. One voltage is balanced against another so there is no current. This allows the use of delicate pickups and long transmission distances without loss of accuracy.

Either of the above types can be used for most control applications, but where the speed of response required is fast, the electronic detection type instrument is preferred. These units use electronic indication in place of the galvanometer and also use electronic followup systems. This provides a low inertia system that has very rapid response without overriding.

In physical appearance, these units are similar to the galvanometer types. Electrically they use either a potentiometer or a Wheatstone bridge circuit and operate on a null balance system. The unbalance is detected, amplified and this signal used to control the phase winding of the followup motor. The circuit is similar to that given in Fig. 4. The control motor then acts to balance the circuit, operate control switches and drive the chart pen.

This type instrument achieves its high stability by using alternating current or pulsing direct current in the amplifier section. This is accomplished by using either an a-c bridge or a vibrator in the d-c potentiometer circuit. By eliminating the instability of d-c amplification and suitably stabilizing the a-c amplifier, these instruments are able to use standard radio tubes. These tubes can be replaced without changing the calibration of the recorder. Normal aging of the tubes does not affect calibration either.

The various circuits employed in these instruments are shown in Fig. 6. In general, the error amplification and followup circuits used are basically the same, but there are various methods employed for indication and for balancing the circuits.

In Fig. 6, two basic detection methods are shown. One is a potentiometer circuit for applications where the transducer signal is a variable voltage. The second is a bridge circuit, a-c excited, for transducers that do not generate a voltage signal, but rather respond to changing external conditions by variations in their internal resistance. Both of these systems incorporate a power driven resistance element to keep the circuit in the nulled state. The motor of this element is controlled by the error amplifier and associated motor phase control circuit.

In the voltage input circuit a standard voltage is nulled against the signal voltage. Any difference or unbalance causes a current to flow thru the input transformer and in order to obtain stable amplification this current is interrupted by means of a vibrator or converter. The resultant pulsing direct current can be amplified by a stable a-c amplifier.

The amplified signal, which has a phase value depending on the direction the unbalance occurs, is used to control the phase of the motor drive tubes. These in turn control the phase winding of the balancing motor and, so, its direction of rotation. The balancing motor rotates the potentiometer resistor and dial pointer until the circuit is nulled.

In the resistance circuit, the converter and battery are not used. An a-c wheatstone bridge is the balance element. In this circuit any change in the resistance of the external element unbalances the bridge and give an a-c error signal to the input transformer that is phase sensitive to the direction of the unbalance. This is amplified and used to control the balance motor as in the potentiometer circuit. In this case the motor changes a resistance in the bridge until the circuit is again in balance.

One other circuit that is of interest has capacitance instead of resistance in the indicating circuit. The signal in this case may be a voltage, a resistance or a variable capacitance. The followup action is driven by two solenoids instead of the motor and acts to

null the circuit by changing the capacitance of a variable condenser.

The important feature of this type electronic instrument is its full scale travel in two sec with an input voltage of 10 millivolts. This rate of response can be decreased to one sec and the sensitivity increased for special applications without loss of stability or overriding.

Many of these units can be obtained with a multiple channel recording feature where each channel is scanned and its reading recorded on the chart. Instruments with over 100 channels are available and these print the record and identify the channel by number, while those with fewer channels use color for identification.

Recent Designs

A relatively new development of this type circuit combines two of the instruments in one case so as to give both *X* and *Y* axis recording. This instrument replaces the time chart drive with a pointer type drive so the chart responds to a variable in the same manner that the pen does. This combination of two variables makes it possible for the instrument to draw curves showing the relation of one variable to the other at any given time. Another variation of the above instrument combines two individual drives on the horizontal scale. This recorder draws continuous curves of two variables against time and actually is two instruments in one case.

Recently several manufacturers have started to market sections of these controllers that can be built into standard indicating instruments to convert them to control units. The vane and coil control can be purchased separately and applied to any pressure gage or moving element so as to give a control action at a chosen point. The amplifier, followup control and servo motor of the electronic units are available as a servo unit that can be built into a special controller. A d-c amplifier with zero drift, similar to that used in the electronic controllers, is available for increasing the sensitivity of an existing controller or building up a signal to usable levels.

Actually these units are standard controllers without cases or auxiliaries and have all the stability and ruggedness of the complete controller. They can be used for special applications by a plain mechanical revision without the need of any further control design.

The standard instruments range in price from about $300 for a plain controller up to $800 for a controller recorder. Dual instruments and double axis instruments range up to $1,400 with multi-channel units priced according to the number of channels. It is interesting to compare these prices with the probable cost of designing an equivalent unit. Assume that a production of 10 machines requiring transducer amplifiers has been scheduled. If a cost of $600 is allowed for each amplifier, a total of $6,000 is available for the project. It is hardly possible that the engineering, material and production costs could be covered by this amount were the job started from the bottom up. The amount certainly would not pay for the cost of field service trials, corrective redesign, preparing instruction manuals, providing for repair facilities and so on.

Applications

The uses these instruments may be put to are limited only by the ingenuity of the designer to provide a suitable transducer to change the effect that is to be controlled into an electrical signal. In general, all control action may be simplified into the control of motion, pressure, flow, temperature, light and humidity. In the chemical field, control is sought for acidity (pH), density, conductivity and chemical analysis. In the electrical field, there are control problems in frequency, voltage, current and power distribution. There are commercially available transducers (table I) to convert these physical, chemical and electrical factors into electrical signals suitable for these controllers.

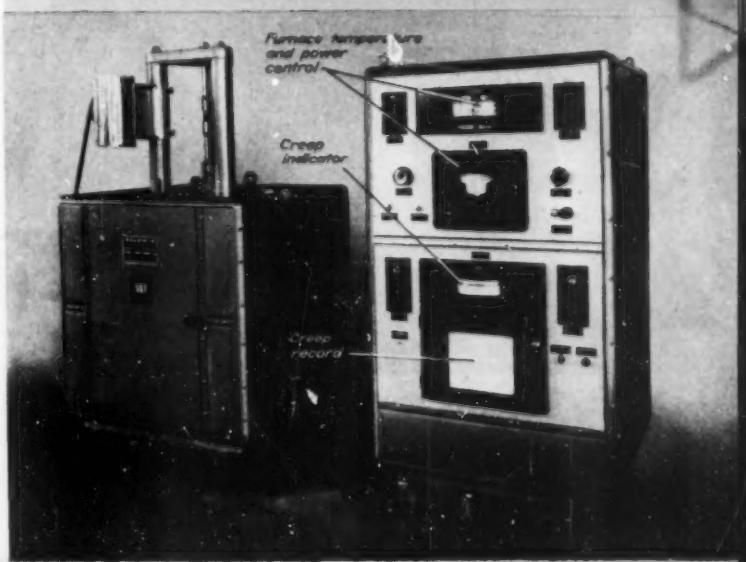
Typical motion transducers are tachometer generators, differential transformers, and variable resistors. Tachometer generators can be used for rpm and surface speed indication while the differential transformer and variable resistor are usually selected for displacement indication.

There are several methods of measuring force and pressure which use either pressure sensitive pickups or strain sensitive pickups. Pressure sensitive pickups are bourdon tubes or bellows used to operate a differential transformer or a low torque variable resistor which converts the pressure into an electrical signal. Another possibility is the strain sensitive transducer incorporating resistance type strain gages bonded to a suitable structural member that deflects under force or pressure. The change of gage resistance due to this deflection is used to convert the force or pressure into an electrical signal.

Flow pickups are similar to pressure types, the flow being changed to pressure by means of flow orifices in the pipes. Temperature pickups employ either thermocouples to generate a voltage or resistance elements to provide a resistance change with a change in temperature. Light pickups, either intensity or monochromatic types, use the output of photo cells for their electrical signals. Units are available for the measurement of all colors, and also for the invisible radiation in the ultraviolet and infrared ranges.

Humidity transducers use the Dunmore element, which has a resistance that varies with humidity. This ele-

Fig. 7—Creep indicator on this fatigue testing machine is actually a modified temperature recorder. Load follow-up action, due to creep, is converted to a resistance signal by a 3 turn variable resistor. Creep is indicated against time by recorder.



ment consists of a polystyrene core, wound with platinum wire in two layers. This is all coated with a hygroscopic film that varies its resistance as the moisture content of the air changes. The two windings are used to sense this resistance change and provide the necessary signal for the controller.

In the chemical field, the transducers are also well developed units that have seen many years of service. The pH pickup is a special cell that changes its voltage output as the acidity of the solution changes, and so gives a signal proportionate to the pH index. For density control and indication, an indicating hydrometer is used. This unit consists of a sampling chamber in which a plummet floats. The center of the plummet or float is metal while the outside of the sampling chamber carries the windings of a differential transformer. As the float changes position due to a density change, the output of the transformer also changes. This a-c output signal is rectified in a bridge circuit, and is then fed to the controller.

One application of these instruments to machine control is shown in Fig. 7. Here, they are used conventionally as a temperature controller and also as a creep recorder for a fatigue machine. In high temperature fatigue testing it is desirable to have a record of creep versus time for the period of the test. In this application, the rotary action of the motor that puts tension in the loading springs acting on the specimen is converted to a change of resistance by means of a three turn variable resistor. This resistor is connected in the bridge circuit of a standard resistance type temperature controller. The only special feature of this instrument is the scale which has lineal markings from 0 to 100.

In Fig. 8, is shown a similar controller modified for a special application. This unit is part of the load governing system for a large fatigue machine. The meter operates as a null indicator and the associated switches are used for low, high and overload control. In place of the chart mechanism, a special panel was installed and this contains the operating controls for the machine. This instrument is a standard unit with four minor modifications, all made at the factory. These changes consist of removing the chart and pen drive, zeroing the pointer in the middle of the dial instead of at one end, putting shorted damping coils on the meter movement to reduce its speed of response and a special unmarked chart. The cost of these special features amounted to about the price of a standard unit, for credit was allowed for parts removed.

In another case, two plain controllers were adapted to the control panel of a large vibration table. One is arranged to scan the temperature of the machine's bearings and shut the unit off if a set limit is exceeded, while the other instrument indicates and controls the speed of the machine. The latter instrument receives its signal from a tachometer generator and is used to automatically cycle the speed of the main drive motor by means of its two control switches. When the speed reaches the top control index, the servo motor is reversed and the machine speed reduced. In like manner, when the speed has dropped to the low index the servo is reversed to increase the machine speed. This circuit gives the same reversal points irrespective of the load on the machine. This instrument also has a damped movement, special dial and special resistors to handle the 80 volt signal. These extras amounted to about $30 above the price of a standard unit.

Elements of these controllers can be used to give special control features to a standard meter. On the machine pictured in Fig. 9, a precision pressure gage was used to indicate load. To the gage was added the vane and coil circuit of a temperature controller to provide load control. The vane was fastened to the pointer and the coils mounted on an adjustable arm that could be set where desired around the scale. In operation, this circuit was triggered when the pointer reached the set pressure and controls were operated to maintain the pressure at this point. The use of this system allowed the pressure gage to be used at full sensitivity and still have a strong positive control action.

In addition to the illustrated circuits and uses, there are many others presently in service. One aircraft company employs 17 units on a test stand to measure torque, thrust, horsepower, pitch angle and temperature. A radiation type unit is being used to identify different products being pumped thru a cross country pipe line so they can be directed to the correct storage tanks. A strain gage type unit is being used to control the calendar pressure on a paper machine to give improved finish to the paper. They are used as CO_2 recorders, smoke recorders and turbidity recorders. Among the latest uses is in jet engine controls.

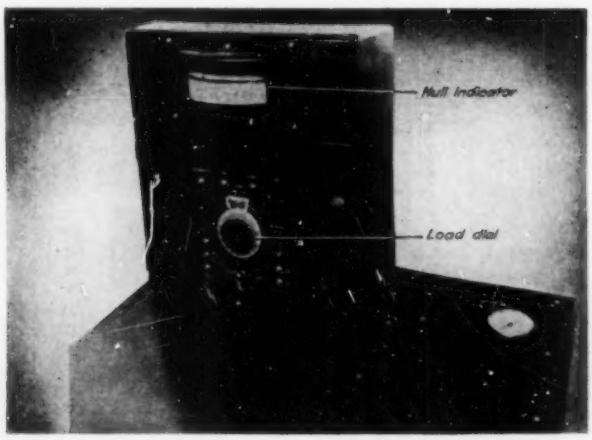


Fig. 8—Modified temperature recorder is part of load governing system for a large fatigue machine. Load signals from a strain gage are amplified by the recorder to operate relays in the control circuit of a load setting motor.

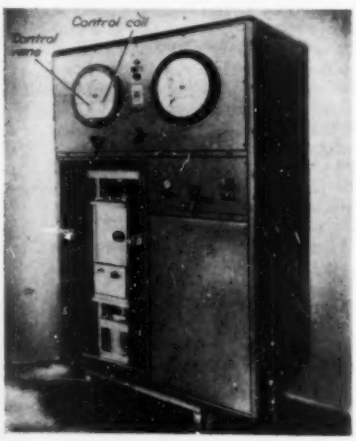
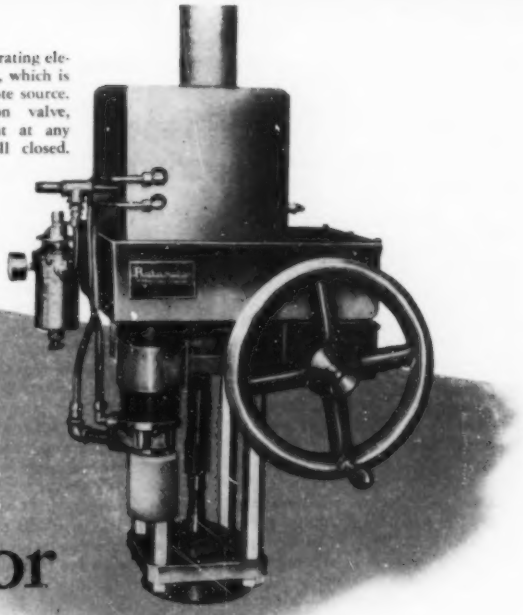


Fig. 9—Hydraulic gages measures leads in this testing machine. When pressure reaches desired value, the pumps are shut down.



HEAVY DUTY ACTUATOR. Operating element of this device is an air motor, which is powered by air supply from a remote source. Actuator can accurately position valve, damper or other control element at any point between full open and full closed.

Pneumatic Actuators for Remote Control Systems

Careful analysis of the load is required in the selection of "pneumatic proportional position operators." These devices convert air pressure from a control source into measured movements of valves, dampers and other elements. When properly matched to the load, these actuators establish the setting of an element with accuracy of ½ of one percent.

D. P. ECKMAN and R. B. WEREY
Conoflow Corporation

AN ESSENTIAL COMPONENT in any pneumatically controlled system is the operator or actuator. Design of this component is especially critical when proportional control, rather than just an on-off action, is called for. In some machines and processes, for example, it may be necessary to regulate the flow of fluid in a pipe at any amount between zero and the maximum rate.

In such applications, the flow control device itself may take many forms, but it is generally a throttling control valve, a damper or a louver. Whatever its form, the operating characteristics of the control device can be no better than those of its actuator. Commonly used actuator types are the spring and diaphragm, the piston, the springless diaphragm and rotary screw stem actuators. The performance characteristics to be looked for embrace not only sensitivity, stability, and accuracy but also the ability to cope with a wide range of force requirements, stem travel, and speeds of response.

Types of Loads

The nature of the load to be handled is an important factor in actuator design. The load, or power output of the actuator, is influenced by the factors of force, travel and speed. Because of the almost unlimited range of power requirements, there is no "universal" actuator. Force requirements vary from a few ounces up to thousands of pounds. Travels vary from a few thousands of an inch up to 60 in. or more. Rates of stem travel can be anything up to one ft per sec or even faster. The proper operator can be selected only after having given due consideration to all of these factors.

The positioning of valves and other control elements involves operating against a number of types of forces in order to obtain a predetermined and exact position of the control element. These forces may be described as (a) pressure load, (b) weight load, (c) inertia load, (d) viscous friction load, and (e) static friction load.

A pressure load exists in all single-seated valves of the globe type and in butterfly valves operating at high pressure differentials. This force is due to the fluid pressure differential acting against the effective area of the restricting plug or vane. It is usually, but not always, unidirectional. Occasionally, the force reverses its direction at wide

openings because the downstream dynamic pressure of the fluid becomes less than the upstream static pressure. The magnitude of the load depends upon the fluid pressures at the valve and upon the effective area of the flow restricting device. Thus,

$$F_p = K_p A P \quad (1)$$

where

F_p = pressure load (lb)
K_p = dimensionless coefficient
A = area of flow restricting device (sq in.)
P = pressure differential across flow restricting device (psi)

The pressure load, therefore, varies as the area of the valve plug and the magnitude of the pressure differential. This accounts for one of the most serious difficulties in positioning against pressure loads, namely the variations in pressure differential. The pressure differential across the valve is rarely ever constant since it generally fluctuates with flow. This imposes a fluctuating load on the actuator.

Weight loads exist in large valves and dampers where the unbalanced weight of moving parts must be supported by the actuator. This force is always unidirectional since it is established by gravitational force and is nearly always of constant magnitude. Therefore,

$$F_w = W \quad (2)$$

where

F_w = weight load (lb)
W = weight of moving parts supported by the motor.

Obviously, the weight load must include the unbalanced weight of the moving parts of the motor operator.

Inertia load is encountered in positioning large butterfly valves where the mass of moving parts is considerable and where the required rate of re-positioning is high. This force arises from the acceleration and deceleration of the moving parts, according to the simple form of Newton's Law.

$$F_i = \frac{W}{g} a \quad (3)$$

where

F_i = inertia load (lb)
W = weight of moving parts
g = acceleration due to gravity—ft/sec^2
a = acceleration—ft/sec^2

An inertia load always acts in the direction of acceleration and thus is not unidirectional. Inertia force is small when the weight and acceleration are small, but the reverse is not necessarily true since it is often possible to counterbalance a weight load.

A viscous friction load may be caused by fluid damping as in a dashpot, by lubricated surfaces as in bearings or in lubricated packing glands. The dashpot establishes a resisting force proportional to velocity. Thus,

$$F_v = b(x)^n \quad (4)$$

where

F_v = damping force (lb)
b = damping coefficient (lb-sec^n-ft^n)
x = velocity (ft/sec)

Generally, it is assumed that the resisting force is proportional to the first power of velocity so that $n \leq 1$ in Eq. 4. Viscous damping exists at well-lubricated surfaces moving over one another. For example, in the packing gland of a valve stem, the viscous damping force may amount to several hundred pounds for a one foot per second velocity whereas the static friction may be negligible. Viscous friction load is a variable depending upon the area of surfaces, their smoothness and the size of packing glands. This type of load always opposes the velocity and thus may act in either direction.

Static friction loads exist at contact surfaces up to the point of relative motion between the two surfaces and are proportional to the normal force between the surfaces. It is usual to assume that the static friction force is given by the expression,

$$F = KN \quad (5)$$

where

F = friction force (lb)
K = coefficient of static friction
N = normal force at surface (lb)

Static friction force always opposes impending motion of the two surfaces and therefore acts in either direction on a motor operator stem.

The separate existence of any one of the five types of forces without any of the other four is never encountered in the ordinary control valve or control element. In fact, all five types of forces co-exist in any motor operator application, although certain of them may not be of sufficient magnitude to be of any consequence.

This fact can be brought out by inspecting several typical control devices for the existence of the five kinds of force. A one-inch, single-seated control valve causes a pressure load on a motor operator by virtue of the pressure differential across the valve plug. The weight load is negligible because the weight of moving parts is small. A viscous friction load exists at the packing gland and, with a tight but well-lubricated packing, this may be relatively high. The static friction load at the packing gland may be large or small depending on the type of packing, and the amount of lubrication.

A typical large butterfly valve has a rotary stem motion so that the various loads are designated as torques. The pressure torque may be relatively large because of the action of the dynamic pressure against the vane (aerodynamic effect). The weight torque is small because the vane is nearly balanced. The inertia torque can be large if the rate of repositioning is high. The viscous friction is moderately small when the packing on the vane shaft is not too tight. The static friction may be appreciable because the full weight of the vane rests on the bearings.

Actuator Types

The spring and diaphragm operator, with its simplicity, ruggedness and low cost, is the oldest type of pneumatic power operator. However, advances in control technology and controller application have imposed demands for more powerful and more versatile operators. Long stroke, a feature in which the spring and diaphragm motor is weak, has been satisfied by new developments in piston and cylinder types of operators. Cylinders also provide a means of obtaining greater thrusts by use of higher air pressures or by pneumatic-hydraulic combinations in which the primary position indication is pneumatic while the piston operating medium is hydraulic.

The ideal performance characteristics of a proportional position operator requires that it establish and maintain any given position within its operating range within plus or minus one half of one percent or less, regardless of the magnitude of load changes. Although this requirement may not seem particularly rigorous in theory, it is often difficult to accomplish in practice, especially with the simpler types of operators.

Spring-Diaphragm and Spring-Piston Motors

The spring and diaphragm motor is widely used for positioning valves, dampers, louvers, and other control devices. As shown in Fig. 1, it consists of a diaphragm clamped around the periphery in a suitable housing, with air pressure applied to one side. A spring opposes the motion of the diaphragm and is designed with a preload. The spring exerts an upward force even when the displacement is zero.

The basic calibration of the spring-diaphragm motor is given by,

$$P_R A = KS \quad (6)$$

where

P_R = maximum operating pressure (psi)
A = effective area of diaphragm of piston (sq in.)
K = modulus of spring (lb per in.)
S = stroke of motor stem (in.)

When operating a spring and diaphragm actuator with either a pressure or weight load acting downward, the maximum initial load must be limited

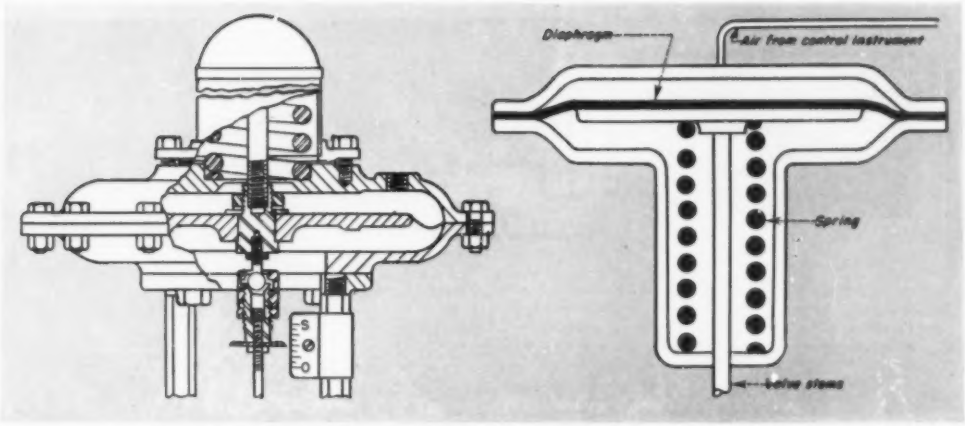


Fig. 1—Conventional spring and diaphragm actuator in cross-sectional and schematic views. Spring is compressed and valve stem positioned in proportion to pressure of air supply.

to the preload in the spring. Otherwise, full up-stroke of the actuator diaphragm could not be achieved. Similarly, should the load act in an upward direction, it must be limited to the overrange pressure to permit full downward travel of the diaphragm. The overrange pressure is defined as the difference between the maximum pressure obtainable from the operating air supply and the pressure required for full downstroke with spring pressure being the only upward thrust acting on the diaphragm.

Usually, spring and diaphragm actuators are designed to be suitable for external loads that act in either direction. The operating range of an actuator is generally set symmetrically so that the spring preload is equal to the overrange load. Thus, the actuator range for a 16 psi air supply may be one to 15 psi, two to 14 psi, three to 13 psi, and so on. With no load, a two to 14 psi actuator completes full downstroke when the operating pressure reaches 14 psi; then returns to the zero position when the pressure drops to two psi. When this same actuator operates with a two lb weight load, full downstroke occurs at 12 psi. If the load is two lb acting upward, full stroke is not completed before 16 psi is reached.

Then the maximum weight load is given by,

$$F_p = F_w = P_o A \qquad (7)$$

where

P_o = initial load (psig)

The diaphragm motor is able to handle only moderate pressure and weight loads. Diaphragm areas cannot be increased much beyond 200 sq in. without the motor becoming unwieldy in physical size. Therefore, the spring and diaphragm motor is limited to pressure and weight loads less than 300-400 lb, even in the larger sizes.

The most serious difficulty encountered in spring and diaphragm motors arises from changing (unsteady) pressure loads. If the accuracy of positioning is to be within plus or minus one-half of one percent of full stroke, then any given value of F_p is limited by the relation,

$$F_p = \frac{P_R A}{200} \qquad (8)$$

For a motor with a 200 sq in. area diaphragm and a 12 psi operating range, the pressure load should not change more than about 12 lb from a given value.

When operating with an inertia load, the diaphragm motor becomes a mechanical oscillating system consisting of a spring and a mass with little damping. The period of oscillation of a diaphragm motor with a 400 lb weight of moving parts and a 3 in. stroke is about 0.3 sec. It is possible that resonance difficulties may be encountered in large spring-diaphragm actuators with large inertia loads.

For operation with viscous-friction load, it is necessary to analyze the equation of motion,

$$\left(\frac{W}{g}\right) x + bx + kx = 0 \qquad (9)$$

where

W = weight (lb)
x = stem position (ft)
b = damping coefficient (lb-sec/ft)
k = spring modulus (lb per ft)

This is the well-known equation of damped vibration and it possesses three typical transient solutions:

1. Oscillatory when gb^2 is greater than $4kW$
2. Critically damped with $gb^2 = 4kW$
3. Overdamped when gb^2 is less than $4kW$

The maximum value of the viscous-friction load coefficient (b) can be determined from limitations given by the desired speed of response of the operator.

Under most operating conditions the motor response will be approximately critically damped or slightly oscillatory. The lag of the motor response in seconds is given approximately by:

$$T = 2W/gb \qquad (10)$$

The maximum viscous friction load is given by:

$$b = 2P_o A/gT \qquad (11)$$

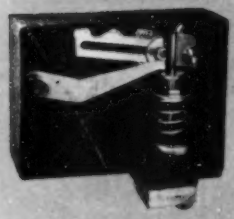
where T is the largest allowable lag in seconds. Thus, for a motor with an inertia load of 400 lb and a lag of 10 sec, the viscous friction load should be less than about 2.5 lb per ft per sec velocity.

When operating with a static-friction load, it is necessary that the motor stem move with a change in applied pressure. Since it is desired that the motor respond to an applied pressure change of at least plus or minus 0.5 of one percent, then

$$F_s = P_R A/200 \qquad (12)$$

The maximum friction force is given by the same relation as that for maximum change in pressure load, equation (8).

This analysis of spring-diaphragm operators shows that the simple spring-diaphragm motor cannot be regarded



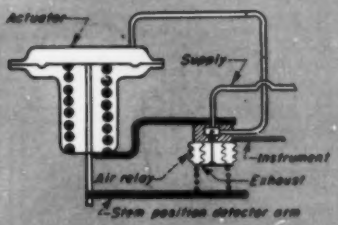


Fig. 2—Picture at left shows lever operated valve positioning relay with cover removed. When used in circuit such as that shown, an air relay allows use of high air pressure for positioning although pressure from the control instrument may be a low value.

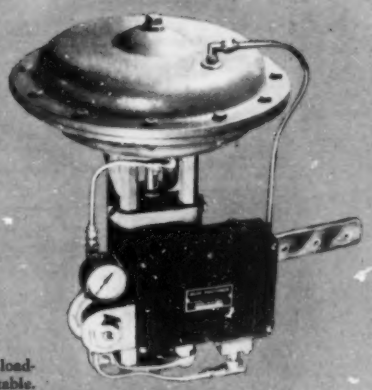


Fig. 3—Springless diaphragm actuator has pneumatic underside loading. Preload on diaphragm, and hence load capacity, is adjustable. In relay circuit, right, diaphragm preload is set by use of hand valve.

as a true positioning device because it is limited by the loads against which it may operate. It is particularly poor in operation under changing pressure loads and static friction loads. In addition, it is generally limited to travels of less than three in. because of difficulties in the design and manufacture of a diaphragm for long travels.

The use of a positioning relay improves the performance of any spring-diaphragm actuator. This device, pictured in Fig. 2 is a pneumatic relay that will place any air pressure on a pneumatic actuator, (up to the limit of the supply pressure), in order to obtain a stem position corresponding to the output pressure of the primary control instrument. The positioning relay employs an auxiliary air supply to drive the stem to the measured position. As such it is a pneumatic servo device. Although the relay does not increase the allowable pressure or weight load when used with a spring and diaphragm motor, it is effective against changing pressure loads because it can automatically counteract changing loads and maintain a fixed motor position. A positioning relay greatly improves operation against viscous friction and static friction loads because of the amplifying actions of the positioner pilot. This amplification action can be as high as 75 to one.

Springless Motors

The springless diaphragm actuator, pictured in Fig. 3, is essentially the same as a spring motor fitted with a positioning relay except for the important difference that in place of a spring there has been substituted constant (though adjustable) underside pneumatic loading obtained by means of a pressure regulator. Such actuators are capable of handling friction and inertia loads equivalent to those handled by spring type actuators, but in addition, have the advantage of being readily adjustable to handle materially larger weight and pressure loads. For example, compare the maximum weight load capable of being positioned through two in. of travel by a spring motor of 100 sq in. area as compared to an equivalent area springless motor. Assume a maximum operating air pressure of 20 psi and a spring range at 16 psi.

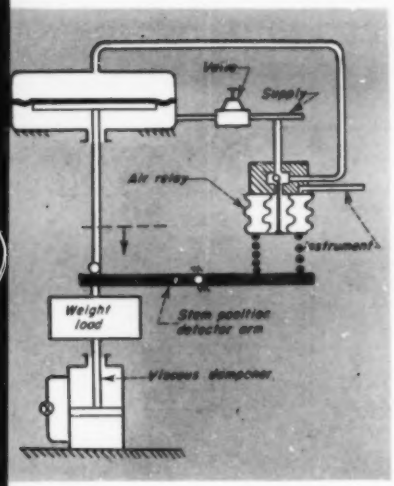
The spring motor would be limited to the two psi preload rating which, according to formula (7), gives it a rating of 200 lb weight load, maximum; the underside loading of the springless motor could be adjusted to about 80 percent of the available supply pressure (16 psi) which would yield a force of 1600 pounds.

Although the springless pneumatic motor can handle large weight loads, difficulties may be encountered at times with the accompanying inertia load. For example, a springless motor with a 100 sq in. area diaphragm and a 30 psi air supply can theoretically handle 3,000 lb of weight load. But if this were actually tried, the inertia of the load might cause the motor operator to oscillate if rates of repositioning were high and if viscous damping were small. An analysis of this situation is beyond the scope of this article, but suffice to say that springless motors of either the diaphragm or piston type are limited to inertia loads less than the corresponding theoretical weight load. No general rule can be given as to maximum inertia load inasmuch as the dynamic operation depends largely upon the design of the positioner pilot and the magnitude of viscous and static friction.

The same principles of operation that are used in the diaphragm type of springless actuator apply also to piston and cylinder combinations. Piston operators permit the use of operating air pressures up to 100 psi whereas the maximum pressure used in diaphragm types is limited to approximately 50 psi by virtue of diaphragm strength limitations. Conventional cylinders, such as are used in the machine tool industry, are, however, unsatisfactory for use in proportional positioning operators, primarily because of the excessive friction associated with leather cup type of packings. In cylinder type operators, such as illustrated in Fig. 4, for proportional positioning service, sealing is accomplished by means of special graphite impregnated O-rings sliding on a highly polished cylinder wall. Such devices provide larger forces and longer travels in a much more compact form than the equivalent diaphragm operator and lend themselves to simpler and more versatile mounting arrangements.

Pneumatic Rotary Motors

The use of a positioning device involving a combination of rotary pneumatic driving motor, gear train, and positioning relay is a relatively new commercial development in the field of pneumatic operators. Such a device is illustrated in Fig. 5. A rotary pneumatic motor drives a threaded



screw stem through a gear train and provides the linear motion necessary for operating large valves and dampers. The positioning relay determines stem position by supplying air at 80 to 100 psi to either the forward or reverse parts of the driving motor.

When operating under pressure or weight loads, the maximum load for this operator is limited only by the available horsepower of the driving motor and the structural strength of the gear train. Thus, the maximum operating load is given by,

$$F_p = F_w = \frac{(HP) \times 550 \times 12 \times t \times E}{S} \quad (13)$$

where

HP = horsepower rating of motor
t = time for full stroke—seconds
S = stroke of motor stem—inches
E = gear train efficiency (approxi. 0.4)

The maximum load that can be handled at any speed is, of course, limited by the stalling torque of the motor.

When operating with an inertia load this system is unusually stable because of the large amount of viscous damping in the gear train, the positive self-locking screw stem and the fact that inertia in the operator itself is very small.

When operating with a viscous friction load the maximum load is limited by the desired speed of travel. The maximum viscous load is given by:

$$b = (HP) \times 550 \times 144 \times E \times \frac{t^2}{S} \quad (14)$$

When operating with a static friction load the maximum load is limited only by the stalling torque of the motor.

The rotary pneumatic motor has advantages other than its ability to handle large loads. For example, with its self-locking gear train, the motor remains in its last position in case of air failure. This feature is often desirable in continuous process industries. Another feature is the ability to provide almost unlimited linear stem travel, either very short or very long without any sacrifice in sensitivity or stability, without materially increasing its physical size.

From the above, it is evident that proper design of a pneumatic operator for proportional position control requires careful consideration of the force loading imposed by the control element. The power characteristics of force, time and speed must be adequate to combat the pressure, weight, inertia, viscous friction, and static friction forces so that the motor operator will possess good performance as to sensitivity, stability, and accuracy.

The ordinary spring-diaphragm pneumatic operator is extremely limited when employed under conditions of changing pressure load or static friction load. Operation of this type of motor can be improved by the use of a positioning relay.

The springless motor of the diaphragm or piston type is an important improvement over spring-diaphragm motors in that it provides for greater pressure loads, longer travels and improved stability and sensitivity.

The rotary pneumatic motor approaches the ideal in handling heavy loads of all kinds. With its self-locking gear train it becomes an extremely stable operator—unaffected by sudden variations in stem loads and line pressures. It can handle long stem travels as easily as short travels without any appreciable increase in physical size.

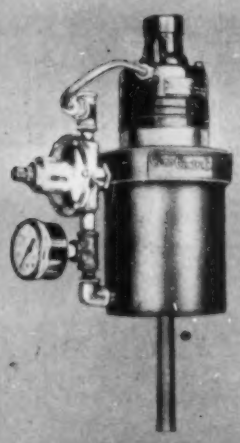


Fig. 4—Cylinder type actuator with built-in air relay. Cross-sectional view shows how preload on piston can be varied by hand valve. The strength provided by piston makes the load capacity of this actuator greater than those employing diaphragms.

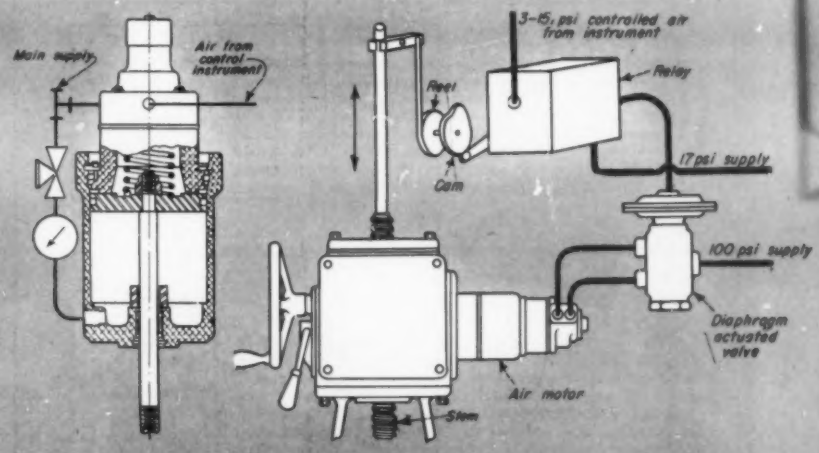
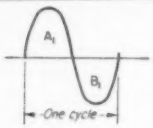
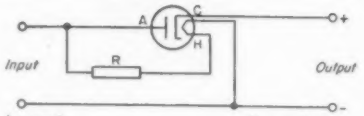
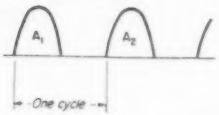
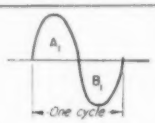
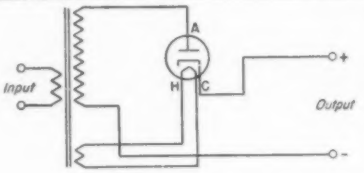
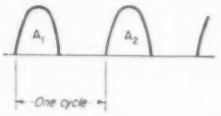
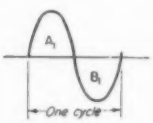
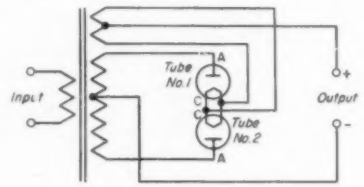
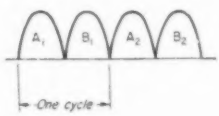
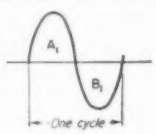
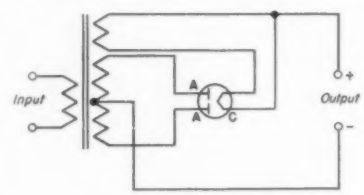
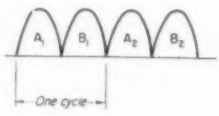
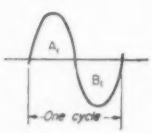
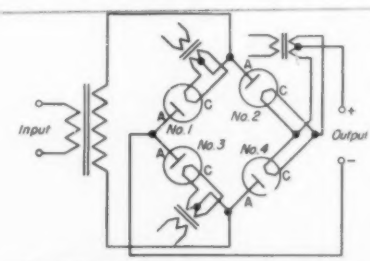
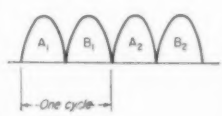


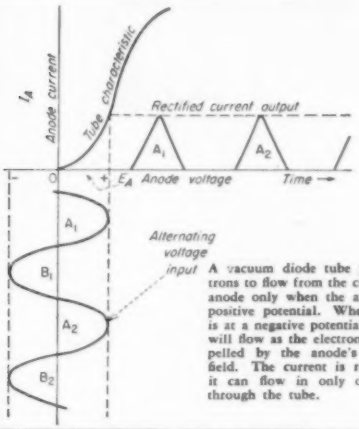
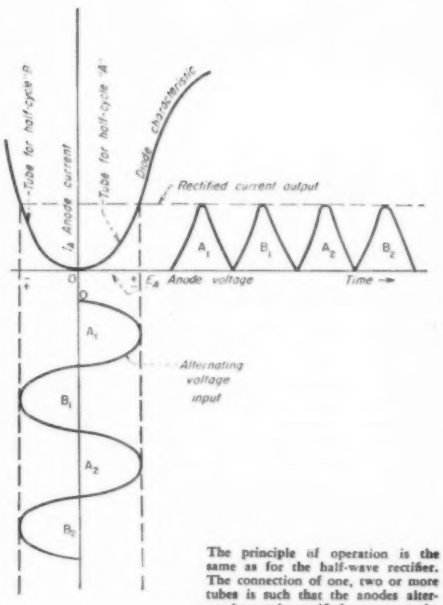
Fig. 5—Schematic of circuit for application of a rotary actuator. Air motor drives the stem through a gear train, which converts rotary to linear motion. It is interesting to note that on this heavy-duty design, the rotary actuator is itself controlled by a diaphragm actuator.

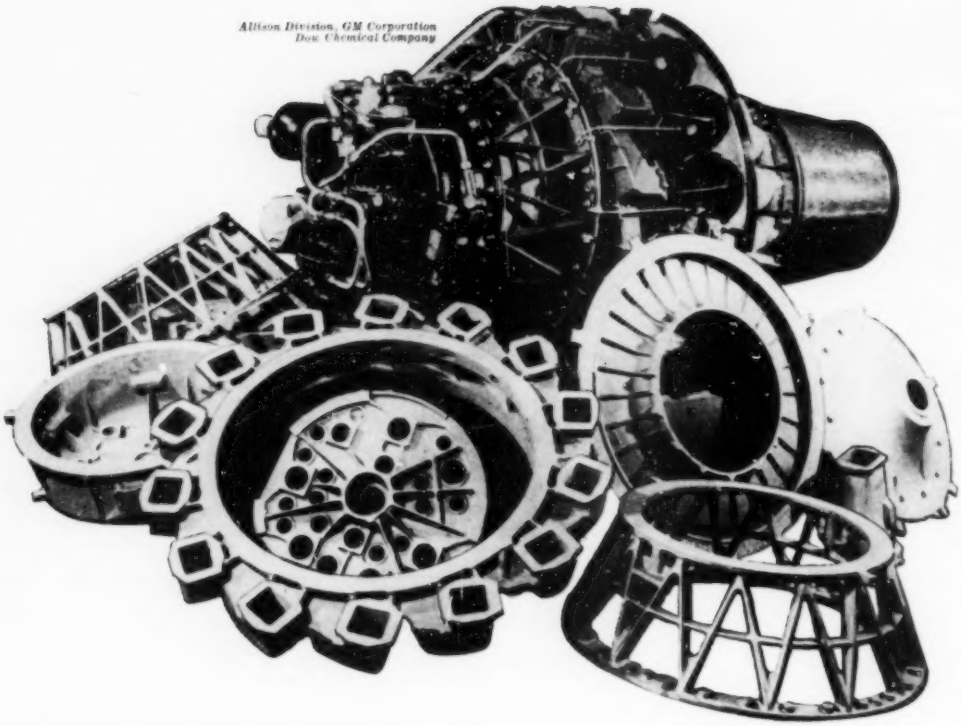
Rectifier Circuits

Type	Input Voltage	Circuit Sketch	Output Voltage
Single Phase Transformerless Half-Wave Rectifier	 f = frequency (a-c sine wave)	 A = anode C = cathode V = average d-c output voltage R = resistor H = heater	 Major ripple voltage, rms = 1.11 V Major ripple frequency = f (Pulsating d-c)
Single Phase Half-Wave Rectifier	 f = frequency (a-c sine wave)		 Major ripple voltage, rms = 1.11 V Major ripple frequency = f (Pulsating d-c)
Single Phase Full-Wave Rectifier	 f = frequency (a-c sine wave)		 Major ripple voltage, rms = 0.472V Major ripple frequency = 2f (Pulsating d-c)
Single Phase Full-Wave Rectifier	 f = frequency (a-c sine wave)		 Major ripple voltage, rms = 0.472V Major ripple frequency = 2f (Pulsating d-c)
Single Phase Full-Wave Bridge Circuit Rectifier	 f = frequency (a-c sine wave)	 Note: Cathode transformers may be separate or wound on iron core of anode supply trans	 Major ripple voltage, rms = 0.472V Major ripple frequency = 2f (Pulsating d-c)

Using Diode Vacuum Tubes

RALPH B. IMMEL
Westinghouse Electric Corporation

Operation	Remarks
 A vacuum diode tube permits electrons to flow from the cathode to the anode only when the anode is at a positive potential. When the anode is at a negative potential, no current will flow as the electrons will be repelled by the anode's electrostatic field. The current is rectified since it can flow in only one direction through the tube.	For some applications, where a low voltage d-c output is satisfactory, it is economical to use this type of power supply. Tubes for this application usually have heaters which are operated at relatively high voltages (35, 50, 70 volts and above. Heaters can be connected across the line, in series with other heaters, or in series with a resistor to limit the voltage to the rated value. This circuit has a disadvantage in that a ground connection cannot be used unless provision is made to insure that the grounded side of the d-c output circuit is connected to the grounded side of the a-c power supply.
	This circuit is advantageous over the transformerless type of half-wave rectifier as the a-c and d-c circuits are isolated. Also, the transformer makes it possible to increase or decrease the d-c output voltage with respect to the a-c input voltage. This type of rectifier is not suitable for some applications as the output voltage is not a continuous value. It is a pulsating d-c voltage. Also, the rectified current flows through the secondary winding of the transformer. This causes changes in the transformer voltage and, hence, further fluctuations in the rectifier output voltage.
 The principle of operation is the same as for the half-wave rectifier. The connection of one, two or more tubes is such that the anodes alternately supply rectified current to the load. A tube conducts only when its anode is at a positive potential.	This is a very commonly used type of rectifier as the output is more nearly constant than that from a half-wave rectifier. There is no d-c iron transformer core saturation because the d-c fluxes in the two secondary windings are opposed to each other and produce a resultant magnetization of zero. Each half of the secondary winding must deliver the maximum output voltage of the rectifier. Thus, the total voltage across the transformer secondary is twice that required for the same peak output voltage from a half-wave circuit.
	A single full wave rectifier tube (double-diode) can be used in place of two half-wave, single-diode tubes to accomplish full wave rectification. For many applications it is satisfactory to connect the positive output lead to the cathode rather than the cathode transformer center tap. The peak voltage for every other half cycle will be different from that of the previous one by an amount proportional to the cathode voltage drop. In a radio receiver, for example, this condition could cause "hum."
	This circuit requires only one secondary transformer winding for the anode voltage. It has some disadvantage in that four tubes are required. Also, more than one filament transformer winding must be used because the cathodes are at different potentials. When the upper end of the transformer winding is at a positive potential, current can flow through tube No. 2, through the load, and return through tube No. 3. When the polarity reverses, tubes No. 4 and No. 1 conduct. This bridge circuit is often used with dry plate rectifiers replacing the tubes.



Allison Division, GM Corporation
Dow Chemical Company

Structural parts subjected to elevated temperatures now cast from standard magnesium alloys are likely applications for . . .

Magnesium

MAGNESIUM is not ordinarily thought of as a structural material for elevated-temperature service in the range from 400 to 600 F. The load-carrying capacity of standard magnesium alloys containing aluminum, zinc and manganese is relatively low at service temperatures above 300 F, and at 600 F, their resistance to failure by creep is slight. But magnesium alloys containing rare earths as the principal alloying element have remarkably good load-carrying capacity even at temperatures as high as 600 F. These alloys are comparable to and, in some instances, better than the best aluminum-base alloys at such service temperatures.

The magnesium-rare earth alloys, first developed in Germany and brought to the attention of American engineers through a study of enemy materiel during World War II can be used in both the cast and wrought forms. As developed in Germany, the cast alloys contained two, four or six percent rare earths and one-and-a-half to two percent manganese. These are now referred to as *EM*22, *EM*42 and *EM*62, respectively. The compositions of the wrought alloys were quite similar, but usually the rare-earth content was in the lower range. The most common of these alloys is the *EM*22 composition.

In general, the load-carrying capacity of the cast alloys increases with rare earth content, though little is gained by using more than six percent. The cast alloys of lower rare-earth content are characterized by lower load-carrying capacity at 550 to 600 F, but better ductility at lower temperatures. The optimum rare-earth content of the wrought alloys appears to be about two percent.

The Air Force, Bureau of Aeronautics and NACA sponsored a study of the magnesium-rare earth alloy to improve their foundry characteristics without sacrificing load capacity in the range from 500 to 600 F. A second objective of this program was to increase the load capacity of the magnesium-cerium wrought alloys in the range from 500 to 600 F, the creep resistance of these alloys being substantially inferior at elevated temperatures to the best cast alloys of similar composition.

Two magnesium-base compositions were developed during this investigation: A cast alloy containing 6.0 rare earths, 0.9 Mn, 0.20 Ni and 0.01 W; and a wrought alloy composed of 2.0 rare earths, 1.5 Mn and 0.20 Ni. The rare earths consist of approximately 50 percent cerium, 25 percent lanthanum, and the balance other rare earths with, perhaps 1.0 percent Fe and other impurities.

The principal foundry characteristic

Table I — Comparison of Average Properties for Experimental and Cast Alloys With Other Cast Alloys*

Alloy	Exp'l Alloy	EM62	E6	EK30		ZREL or EZ33[1]**	142-T61
Condition***	HTAS	HTAS	HTAS	HTAS	HTA[1]**	Aged	Stabilized
Nominal Composition	Mg, 6%Ce 0.8%Mn 0.2%Ni 0.02%W	Mg, 6%Ce 1.7%Mn	Mg, 6%Ce	Mg, 3.25%Ce 0.55%Zr		Mg, 2.75%Ce 2.75%Zn 0.6%Zr	Al, 4%Cu 0.6%Fe 0.8%Si 1.5%Mg 2%Ni 0.2%Ti
Grain Size, in. (heavy sections poured at 1,450 F)	0.04	0.4	0.12	—	—	—	0.04
Tensile Strength, psi							
Room Temperature	17,850	15,400	17,750	—	22,900	20,300	37,000
400 F	16,375	15,000	—	—	20,000	20,100	22,000
600 F	13,900	10,900	10,900	8,000	11,800	8,900	8,000
Yield Strength, psi (0.2 percent offset)							
Room Temperature	17,850	15,400	17,750	—	16,500	12,300	32,000
400 F	7,950	8,650	—	—	14,000	10,500	25,000
600 F	7,050	6,000	5,100	3,950	7,700	6,200	4,000
Elong in 2 in., percent							
Room Temperature	1.0	0.8	0.8	—	2.4	4.0	0.0
400 F	4.5	2.8	—	—	13.1	22.0	0.5
600 F	36.3	30.2	43.0	75	69.0	64.0	10.0
C_L = Load, to produce 0.5 percent deformation in 100 hr at 600 F, psi	3,100	3,100	1,700 (HTA)[1]	—	1,700	1,900	4,900
$C_L \div$ Density	1,680	1,680	950	—	940	1,040	1,700
Minimum Creep Rate, percent/hr, 600 F, 2,500-psi, load	0.0007	0.0007	0.004	Very high —		—	0.00017
Total Deformation at 120 hr at 600 F under 2,500 psi, load, percent	0.12–0.14	0.15–0.23	1.4	5.5	—	—	0.05

* Data based on few tests only.

** Tensile data on these alloys at 600 F in the A (aged) or HTA (heat treated and aged) conditions are fictitiously high because they were not stabilized at test temperature.

*** Properties of experimental alloy, EM62, and E6 at room temperature for HTA condition.

[1] Data taken from "Casting of Magnesium-Cerium Rare Earth Zirconium Alloys in Sand Molds", by H. E. Nelson and F. P. Strieter, A.F.S., 1950

Rare Earth Alloys

L. W. EASTWOOD
Battelle Memorial Institute

Cast alloys containing up to six percent rare earths and wrought alloys with about two percent rare earths have high creep resistance at 600 Fahrenheit. Foundry characteristics of cast alloys are above average.

of the *EM*62 alloy (6.0 Ce, 1.7 Mn) is its coarse grain and resulting extreme hot shortness, which makes it difficult to obtain castings free of cracks. The experimental alloy mentioned above is much finer grained, as illustrated in Fig. 1 and is less hot short in the foundry. Because the metal solidifies within a narrow temperature range and with a large amount of eutectic at the end of the freezing range, it is not nearly as subject to microporosity as are the standard casting alloys of magnesium containing aluminum and zinc. Superheating is not necessary to obtain adequate grain refinement by such methods, but sound gating techniques are required when making castings of the experimental alloy because it readily forms dross if turbulence occurs during pouring. This is true, of course, of all magnesium-base alloys, but it is particularly true of those containing the easily-oxidized rare earths.

The experimental wrought composition given above has fabricating characteristics similar to other magnesium-base alloys, but, because of greater strength at elevated temperatures, more power is required for hot working. The alloy can be forged like other magnesium-base alloys, but forging is most successful when extruded stock is used and forging is done in a press. The alloy can also be extruded, and both extruded and cast slabs have been successfully hot rolled in the laboratory. As yet, wrought products of this alloy have not been made on a commercial basis.

Properties of the Cast Alloy

Considerable data are available dealing with the effect of temperature on the tensile properties and creep resistance of the cast alloy (Grube and Eastwood: "Magnesium-Cerium Cast Alloys for Elevated-Temperature Service", A.S.T.M. 1950). The effects of temperature on tensile and yield strengths of the experimental alloy, *E6* (6.0 percent rare earths), and *EM*62 (6.0 percent cerium and 1.7

percent Mn) alloys are shown in Fig. 2. It is quite evident that, in addition to the previously mentioned improved foundry characteristics, the experimental alloy has higher tensile properties, especially in the 500 to 600 F range.

A comparison of the tensile properties and creep resistance of the experimental cast alloy with four other magnesium-base alloys, containing cerium and the aluminum-base alloy, 142-T6, is listed in Table I. It will be noted that the high-temperature properties of the experimental alloy compare favorably with *EM*62, but, as indicated previously, it has the advantage of markedly improved foundry characteristics. Its load-carrying capacity at 600 F is appreciably superior to those of *E*6, *EK*30 or the British alloy *ZREL*. Alloys in the aged, or heat-treated and aged condition have not been stabilized prior to test and, consequently, their tensile properties will be appreciably better than if the alloys had been stabilized at temperature prior to test. When the alloys are stabilized, they are heated for a prolonged period at the test temperature, or for a shorter time at a higher temperature in order that the structure of the alloy will become stable and not undergo further change with continued exposure to the elevated temperature. If the intended service life is for a prolonged period at elevated temperature, property comparisons should be made when the alloys are in the stabilized condition because, after prolonged service at the operating temperature, the alloys will approach this condition. This is well illustrated in Table I. At 600 F, the tensile and yield strengths of the *EK*30 alloy differ greatly depending upon whether the *HTAS* (stabilized) or *HTA* condition is considered.

Table II — Comparison of Average Properties for Experimental Alloy of Optimum Composition With Other Wrought Alloys*

Alloy	Exp'l Alloy	EM22	32ST**	18ST**
Nominal Composition	2%Ce†, 1.5%Mn, 0.2%Ni	2%Ce, 1.5%Mn	0.9%Cu, 12.5%Si, 1.0%Mg, 0.9%Ni	4%Cu, 0.5%Mg, 2.0%Ni
Tensile Strength, psi				
Room Temperature	30,500	34,000	54,000	63,000
400 F	18,000	16,500	16,000	20,000
600 F	12,000	10,000	6,000	5,000
Yield Strength, psi (0.2 percent offset)				
Room Temperature	28,000	30,500	46,000	47,000
400 F	12,000	10,500	11,000	15,000
600 F	8,200	7,000	3,500	3,000
Elong in 2 in., percent				
Room Temperature	4.0	5.0	8.0	17.0
400 F	26.0	26.0	30.0	26.0
600 F	100.0	90.0	60.0	65.0
C_L = Load in psi to produce 0.5 percent deformation in 100 hr at 600 F	2,800	2,300	2,300	3,000
$C_L \div$ Density	1,550	1,270	860	1,070
Creep Rate, percent/hr 2,500-psi load at 600 F	0.001	0.01	0.1	0.001
Total Deformation in 120 hr at 600 F under 2,500-psi load, percent	0.205	1.0	—	—

* Materials in heat treated, aged and stabilized condition.
** Data from Air Force Project RAND Report, R104, "The Effects of Temperature on the Properties of Aluminum Alloys", by C. M. Craighead, L. W. Eastwood, and C. H. Lorig, August, 1948.
† Ce indicates rare earths, not cerium.

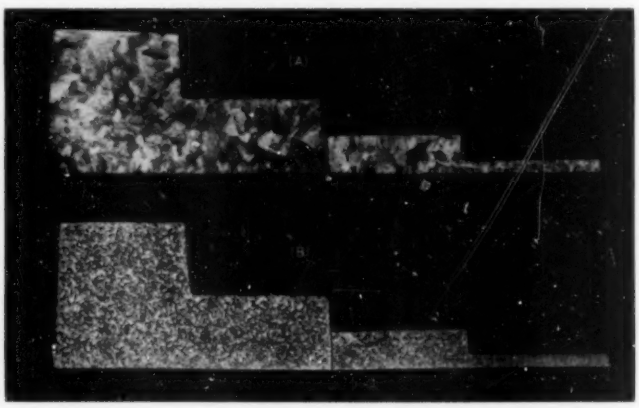


Fig. 1—Macrostructure comparison between *E*6 and *EM*62 magnesium-base alloys. Both contain 6.0 percent rare earths (Ce) and were poured at about 1,415 F. *E*6 (a) has 2.0 percent Mn and *EM*62 has 0.6 Mn, 0.2 Ni and 0.02 W. Finer grain structure of *EM*62 results in a casting having markedly improved resistance to hot cracking.

Other data are available (Grube and Eastwood, "Magnesium-Cerium Wrought Alloys for Elevated-Temperature Service" A.S.T.M. 1950), which show the improved creep resistance of the experimental alloy. For example, if the maximum permissible total deformation is 0.5 percent, the experimental wrought alloy will support 2,500 psi at 600 F for 450 hr. The *EM*22 composition will support the same stress for only 60 hours.

A comparison of the average tensile and creep properties of the experimental wrought alloy with those of the magnesium-cerium alloy *EM*22 and the two aluminum-base alloys, 32S-T and 18ST, is given in Table II. The load-carrying capacity of the experimental alloy is appreciably better than the other three alloys at 600 F. The aluminum-base alloys, of course, have better load-carrying capacity at room and slightly elevated temperatures.

Applications

The compositions of both experimental alloys were developed for maximum load-carrying capacity at 600 F. A comparison of these alloys with other alloys will, therefore, be most favorable at 600 F and generally less favorable at temperatures which are lower, for example, 400 F. The Brit-

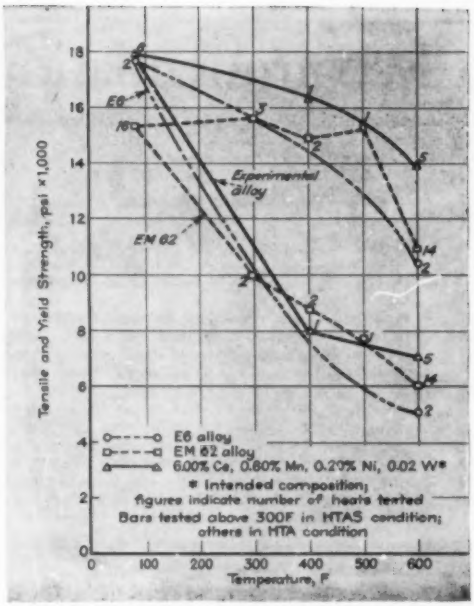


Fig. 2—Comparison of yield and tensile strengths of *E6*, *EM62* and experimental alloys in range up to 600 Fahrenheit

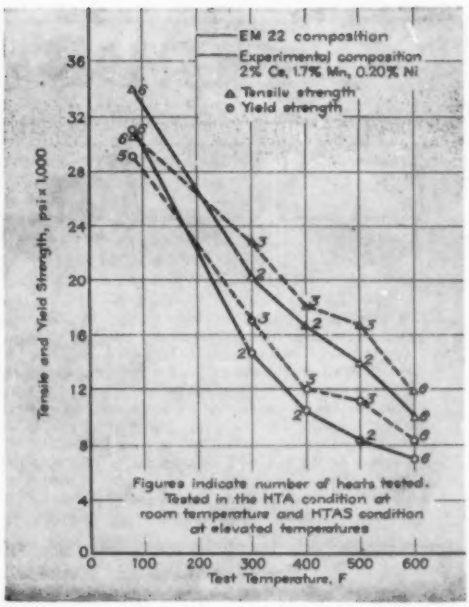

EM 22 composition
Experimental composition
2% Ce, 1.7% Mn, 0.20% Ni
Tensile strength
Yield strength
Tensile and Yield Strength, psi x 1,000
Test Temperature, F
Figures indicate number of heats tested.
Tested in the HTA condition at
room temperature and HTAS condition
at elevated temperatures

Fig. 3—Effect of temperature on tensile properties of extruded *EM22* alloy and experimental alloy containing nickel.

ish alloy ZREL (Table I), for instance, is designed especially for operation in this lower temperature range.

The two new alloys could be used where cast wrought magnesium-base alloys are suitable, except that the service temperature in the range of 500 to 600 F is too high for the magnesium alloys containing aluminum and zinc, or even for such alloys as EK30 and ZREL. Accordingly, the principal intended use for the two experimental alloys is for cast and forged parts of aircraft engines and, to a lesser extent, for airframe parts operating at 500 to 600 F. In such applications, standard methods of surface protection are necessary because corrosion resistance of the new alloys is relatively low, especially in marine atmospheres.

In view of the demand for greater output of aircraft power plants and the ever-increasing temperature range of operation, it is believed that both these magnesium-cerium alloys will be of considerable future interest.

Power Tool Show Visits French Workers

PARIS—A dramatic new method of presenting productivity to the man-in-the-street is now blazing the trail round France. Allying popular appeal with practical technical demonstrations, the Economic Cooperation Administration and the French National Productivity Committee have jointly worked up a traveling exhibition of modern hand tools, "L'Exposition Routiere de l'Outillage Portatif."

The show consists of several hundred of the most up-to-date power hand tools produced in both France and the U. S. transported in a green and yellow truck and trailer. The gaily coloured caravan also compactly contains a 52½ x 16½ ft exhibition tent, as well as compressed air and electric power generators.

Outstanding among the French exhibits is a 7 mm elliptical hand-saw. Two types are demonstrated, the Ellipsi, an electrically driven model, and a pneumatic job manufactured by Les Forges de Meudon. Its double blade can whip elliptically through the middle of any beam, and is particularly useful in producing mine equipment such as pit-props. This type is unknown in the States, and Thor is probably buying the U. S. patent.

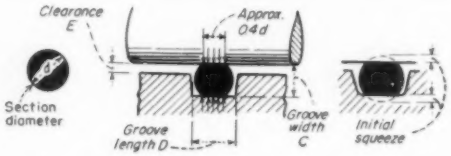
Other highlights of the show are a small metal-cutter that bites through a one-quarter inch steel plate as easily as if it were slicing bread, a pneumatic bolt driver capable of tightening ten to twenty bolts a minute, and a couple of pneumatic circular saws.

Certain other exhibits, although widely used in the U.S.A., are so far little known to French workers. These include pneumatic and electric hammers and saws, other portable wood-cutting tools, high cycle electrical equipment and sheet-cutting machines. All the tools on display are mass produced.

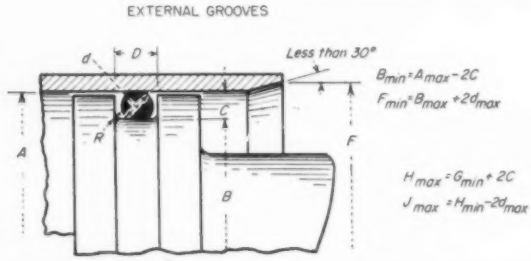
Half the material was shipped especially from U. S. manufacturers to their Paris representatives, who will be able to sell it to eager French industrialists once the junket is over. The balance is lent by French manufacturers. The exhibition is strictly non-commercial, and no orders are taken by demonstrators whose aim is purely educative. However, industrialists especially interested in certain tools may request a demonstration in their own plant, and sales representatives are notified in advance to stand by in the various centers visited.

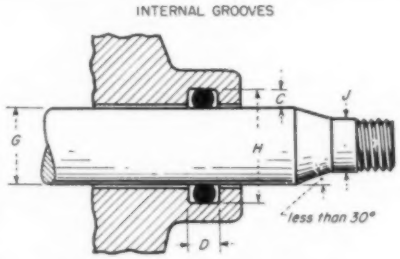
Design Recommendations

1 Rectangular grooves are recommended for most applications, whether static or dynamic. Slightly sloping sides (up to 5 deg) facilitate machining with form tools. Where practical, all groove surfaces should have the same degree of finish as the rod or cylinder against which the O-ring operates. The Vee type groove is used for static seals and is especially effective against low pressures. The dovetail groove reduces operating friction and minimizes starting friction. The effectiveness of the seal with this groove is critical depending upon: pressure, ring squeeze and angle of undercut. In general, the groove volume should exceed the maximum ring volume by at least 15 percent.

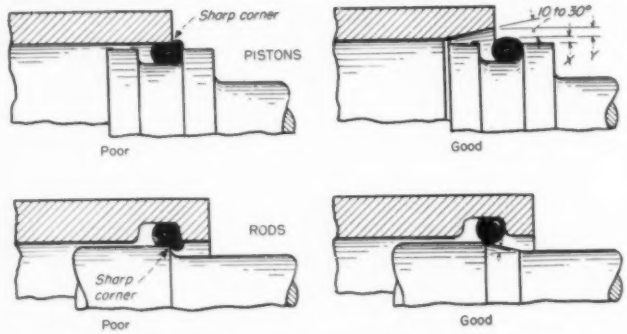


2 To insure a positive seal, a definite initial squeeze or interference of the ring is required. As a rule, this squeeze is approximately 10 percent of the O-ring cross sectional diameter *d*. This results in a ring contact distance of approximately 40 percent under zero pressure and can increase as much as 80 percent of the cross section diameter depending on pressure and composition of the ring. Starting friction can be reduced somewhat by decreasing the amount of squeeze but such a seal would be only moderately effective at pressures above 500 psi. Table I lists the recommended dimensions and tolerances for O-ring grooves for both static and dynamic applications.

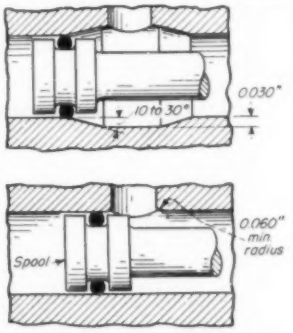




3 On small diameters, to facilitate machining, O-ring grooves should be located on the ram or rod rather than on an inside surface. For larger diameters, grooves can be machined either way. One important factor is that the rubbing surfaces must be extremely smooth. The recommended dimensional data in Table I and listed under dynamic seals should be used for these applications. All cylinders and rods should have a gradual taper to prevent damage to the O-ring during assembly. Equations are listed for calculating limiting dimensions for both external and internal grooves.



6 To facilitate assembly, all members which slide over O-rings should be chamfered or tapered at an angle less than 30 degrees. An alternative method is to use a generous radius. Such details prevent any possibility of pinching or cutting the O-ring during assembly.



7 Undercut all sharp edges, or cross-drilled ports over which O-rings must pass. While under pressure, rings should not pass over ports or grooves.

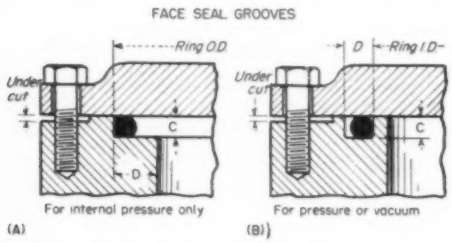
for O-Ring Seals

J. H. SWARTZ
Linear, Inc., Philadelphia, Pa.

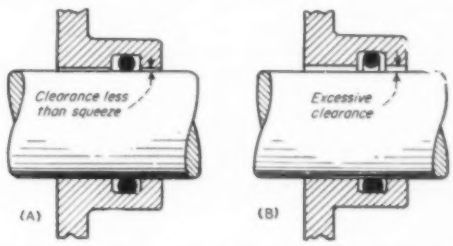
Table I—Dimensional Data for Standard AN or J.I.C. O-Rings and Gaskets

Specification AN 6227 or J. I. C. O-Ring Dash Number	Nominal Ring Section Diameter	*d* Actual Section Diameter	For Static Seals: Diametral Squeeze* (minimum)	For Static Seals: *C* Groove Width +0.000 −0.005	For Dynamic Seals: Diametral Squeeze* (minimum)	For Dynamic Seals: *C* Groove Width +0.000 −0.001	*D* Groove Length**	*R* Minimum Radius	2*E* Diametral Clearance (maximum)	Eccentricity (maximum)
1 to 7	1/16	0.070±0.003	0.015	0.052	0.010	0.057	3/32	1/64	0.005	0.002
8 to 14	3/32	0.103±0.003	0.017	0.083	0.010	0.090	9/64	1/64	0.005	0.002
15 to 27	1/8	0.139±0.004	0.022	0.113	0.012	0.123	3/16	1/32	0.006	0.003
28 to 52	3/16	0.210±0.005	0.032	0.173	0.017	0.188	9/32	3/64	0.007	0.004
53 to 88	1/4	0.275±0.006	0.049	0.220	0.029	0.240	3/8	1/16	0.008	0.005
AN 6230 or J. I. C. gaskets 1 to 52	1/8	0.139±0.004	0.022	0.113	——	——	3/16	1/32	0.006	0.003

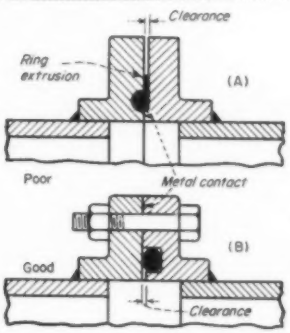
Note: All dimensions are in inches.
* Diametral squeeze is the minimum interference between O-Ring cross section diameter *d* and gland width *C*.
** If space is limited, the groove length *D* can be reduced to a distance equal to the maximum O-Ring diameter *d* plus the static seal squeeze.



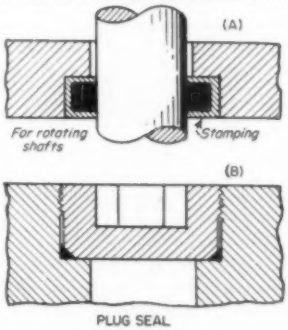
4 For static face seals, two types of grooves are shown. Type (A) is more commonly used because of simpler machining. Groove depths listed in Table I under static seals apply to this application. In high pressure applications where steel flanges are used, slight undercutting of one face (not exceeding 0.010 in.) minimizes possible O-ring extrusion.



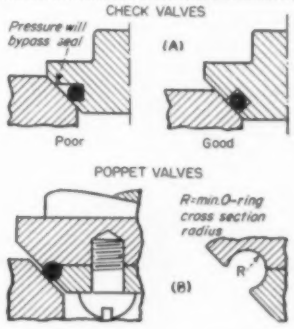
5 Radial clearances should never exceed one-half of the recommended O-ring squeeze even where the pressure does not require the use of a close fit between sliding parts. Under these conditions, if the shaft is eccentric (A), the ring will still maintain its sealing contact. (B) Excessive clearance results in the loss of sealing contact of the O-ring.



8 Metal-to-metal contact of the inner mating surfaces (A) should be avoided. Clearances should be permitted only on inner surfaces (B).



9 Simple stamping (A) pressed in housing is for low speeds and pressures. (B) Chamfered corners of plug makes a recess for an O-ring.



10 Rectangular grooves (A) should be normal to the sealing surface. Special grooves (B) avoid the washout of O-rings during pressure surges.

Electro-Dynamic Calibrators for Vibration Pickups

ROBERT C. LEWIS
The Calidyne Company

THE SEVERE MECHANICAL TREATMENT to which vibration pickups are subjected during use requires periodic verification of their dynamic performance. As calibration of these sensitive devices by reference to basic standards of voltage, displacement and frequency is generally difficult, various techniques have been developed for doing the job in a rapid, yet accurate manner.

One such method is the use of a calibrator with which the performance of a pickup is compared to the known performance of a secondary standard. The elements of this calibration system consist of: (1) A generator of the mechanical motion to which the pickup's electrical output has a presumably flat response—velocity for a velocimeter and acceleration for a accelerometer; this type generator should produce a sinusoidal function of the desired motion, which is variable in frequency throughout a given range. (2) An electrical signal output related to the generated mechanical motion in some fundamental way, such that the relationship can be verified by calibration against standards over a certain frequency range.

This arrangement amounts to a "built-in" pickup of the same general category as that to be calibrated—one that can be standardized by the same tedious procedures ordinarily used for the fundamental calibration of a pickup. But the difference is that, once the set-up is standardized, routine calibrations can be made by comparing the output of the secondary standard with the pickup to be calibrated when both are subjected to the identical motion. Such a calibration consists in accurately establishing a voltage ratio, which is generally a relatively simple matter.

An electro-mechanical shaker is a generator of sinusoidal velocities or accelerations. As pointed out in the article "Applying Shakers for Product Vibration Analysis," (PRODUCT ENGINEERING, November 1950, page 150), the force generated at the armature of such a shaker is proportional to the current passing through the armature coil. If the frequency of this current is high relative to the natural frequency of the armature on its flexure supports, the acceleration of the armature will be proportional to the current and the waveform of the alternating acceleration so generated will be as good as the waveform of the current passed through the coil. Such a shaker fills the first requirement for an accelerometer calibrator.

This fundamental relationship of

Comparison of Accelerometer and Velocity Pickup Calibrator Characteristics

Calibrator Characteristics	Accelerometer Calibrator	Velocity Pickup Calibrator
Natural frequency	1.75 cps	10 cps
Driving circuit	direct coupled	transformer coupled
Useful frequency range	0.5 cps up	5 to 7 cps up
Usual calibration range	4 to 500 cps	10 to several thousand cps
Signal calibrated as secondary standard	driver current	open circuit voltage of special built-in pickup
Standard signal proportional to	acceleration	velocity
Limitations	(a) known (or constant) mass on calibrator (b) 1st structural resonance of system	(a) known dynamic behavior of built-in pickup field (b) failure of pickup coil to move with pickup under calibration
How established	primary calibration and phase measurements	(a) mounting of calibrator (and integral pickup field) on massive, nonresonant mounting (b) primary calibration and phase measurements

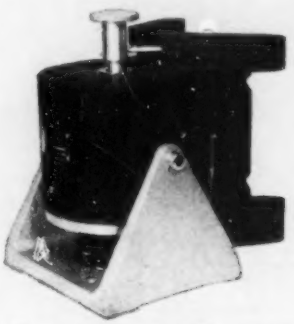


Fig. 1—Accelerometer calibrator, having a standard electrical signal for range from four to 500 cycles per second.

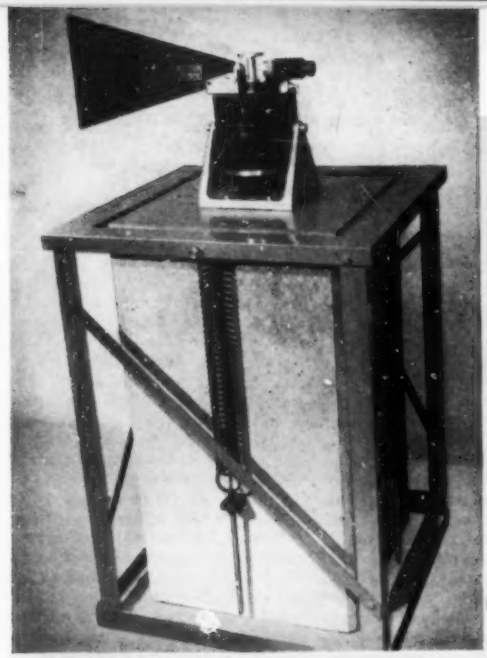


Fig. 3—Calibrator stand consists of 1,500-lb concrete block, spring-suspended to provide a dynamically-stationary reference frame.

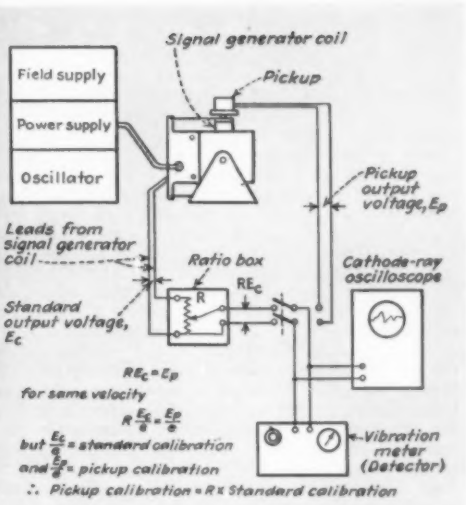


Fig. 4—Diagram of velocity calibration system. Detector is used to indicate level of pickup output, then switched to indicate level of a portion of the standard output. This portion is adjusted to equal the pickup output, making the pickup calibration equal to the determined fraction read from the ratio box, times the standard calibration.

driving current to acceleration waveform, obtained with a shaker, is in direct contrast to the use of a mechanical table that is made to execute a sinusoidal displacement through a cam. Slight variations in the cam motion caused by bearing roughness or grinding marks produce negligible variation in the displacement waveform. But the acceleration waveform is useless for calibration purposes because of the "hash" produced by these small variations, which influence the acceleration in proportion to their displacement amplitude multiplied by the square of the frequency relative to the fundamental motion of the cam. The mechanical table is essentially a displacement generator, and hence does not satisfy the first requirement for a calibrator of accelerometers.

Fig. 2 — Velocity pickup calibrator, having a standard electrical signal proportional to velocity.

To meet the second requirement of a calibration system, advantage is taken of the fundamental relationship between current and force, and therefore between current and acceleration in the armature system at frequencies above that of the suspension. To make available as wide a range of frequencies as possible, the calibrator illustrated in Fig. 1 has a natural frequency of 1.75 cps. This permits generation of an acceleration waveform at a low frequency by virtue of an amplifier whose output stage is direct-coupled to the high-impedance center-tapped coil of the calibrator unit. The electrical signal taken from the armature coil current can be verified as a secondary standard of acceleration over a frequency range from four to 500 cps, resonance-free.

Similarly, a velocity-pickup calibrator can be devised using an electrodynamic shaker as the generator of pure sinusoidal velocity. An electrical signal can be produced by a coil attached to the armature and caused to move in the field of a magnet structure attached to a reference frame. The voltage produced by such a device is proportional to the velocity of motion through a fundamental relationship of electro-mechanics, and therefore serves as a good secondary standard after calibration. In Fig. 2, is illustrated such a velocity calibrator.

Secondary Standard Requirements

The successful operation of a calibration system based on the use of a secondary standard requires three essentials: A good understanding of the theoretical assumption and practical consequences limiting the validity of the standard signal; a dynamically suitable installation; and adequate calibration and periodic checking of the secondary standard.

The theoretical assumption made is that the calibrator armature with the pickup under calibration constitutes a single-degree-of-freedom system throughout a specified frequency range. Deviations from this assumption are of various kinds, and their influence on the accelerometer and velocity calibrator is manifested in different ways, some of which are summarized below.

The armature motion coincides with the pickup motion only if the pickup is firmly attached thereto, but much difficulty arises when this assumption

is made. Care should be taken to eliminate rocking or bouncing at high accelerations, and attention given to the assumption that the attaching flanges of the pickup or the armature system itself are sufficiently rigid at the frequencies involved to justify the assumption of uniform motion. The motion of some accelerometers has been found to exceed the base motion by a substantial percentage because of flexure in the mounting flanges. Even at moderately high frequencies it is not safe to assume that measurements of velocity taken at one end of an armature system are the same as those sustained by a pickup mounted on the opposite end.

A second source of deviations from the assumed simple conditions arises through an actual difference in the frame of reference for the standard and the pickup under calibration. As an example, a velocity pickup under calibration has as its frame of reference fixed coordinates in space, while the secondary standard may have its coil attached to the armature, as is the pickup, and its magnetic structure attached to the shaker frame. Should the shaker move, because of flexibility or resonance of its supporting structure, the standard pickup measures a relative motion of the armature and shaker, which is different from the armature motion relative to fixed coordinates. A resonance of the mounting structure of an accelerometer calibrator is not of concern insofar as effect on the standard signal is concerned, because the signal is derived from the acting force, which has an equal reaction regardless of whether the source of the reaction backs away or not. In the case of the accelerometer calibrator, a good mounting is also preferable to allow freedom from similar difficulties that sometimes develop during standardization.

One solution to the problem of mounting lies in a simply-constructed calibrator stand, such as the one shown in Fig. 3. This stand consists of about 1,500 lb of concrete capped by a carefully grouted and bolted steel plate supported by coil springs. All suspension frequencies of this block are below two cps, and yet the stability is good. Such a calibrator stand serves as a dynamically stationary frame to which the calibrator can be firmly bolted. This frame is also an excellent medium for isolating extraneous ground vibrations from the calibration setup.

The useful frequency range of a velocity calibrator is limited by the range over which the standard signal reference frame is stationary, and the frequency at which the standard signal coil undergoes motion relative to that of the pickup under calibration. A sensitive way of checking deviations from the assumed similarity of dynamic behavior is to compare the output of the pickup and standard signal on the horizontal and vertical plates of cathode ray oscilloscope. Phase shifts occurring within a given frequency range can then be observed.

Unlike the accelerometer calibrator, the velocity calibrator can be used near flexure resonances by "detuning" the flexure supports with movable, padded masses, provided the identity of motion between signal generator and pickup is not disturbed.

The useful frequency range of an accelerometer calibrator extends between the frequency of the armature system on its support and the first resonance of the armature and/or flexure system. Because of its careful design for wide resonance-free range, such a calibrator is a good phase reference when calibrated, and is a valuable aid in checking the damping of accelerometers by the sensitive phase vs frequency-ratio method.

Assuming that the calibrator signal has been adequately standardized, the procedure for the calibration of a pickup is shown in Fig. 4. For a velocity calibration, the armature with standard signal generator and attached pickup is subjected to a sinusoidal velocity by the oscillator-power amplifier system. As a result of the oscillatory velocity, both the signal generator and the pickup produce voltages. Assuming that the signal generator voltage is larger than the pickup voltage, a fraction of the former can be selected to equal the latter. This fraction can be read directly from a calibrated ratio box, which is varied until a detector shows equality between the pickup signal and the set fraction of the standard signal. Since both pickup and standard are subjected to the same velocity, the pickup calibration in volts per inch per second is equal to the determined fraction multiplied by the standard calibration constant.

The calibration so obtained depends only upon the accuracy of the standard calibration and the experimental accuracy of the ratio determination. It is independent of the actual frequency velocity level, or the accuracy of the detector used, which only indicates a condition of equality between identical signals. If a calibrated detector is used, such as a vibration meter, a rapid means of monitoring the vibration level is obtained. Such calibrations, either on the velocity or acceleration calibrator, can be made at varying levels for amplitude linearity checks and at various frequencies with great rapidity and precision.

New Techniques for Koldwelding

SIGNIFICANT DEVELOPMENTS in the application techniques of Koldwelding have been revealed by the Koldweld Corporation of New York City. This new method of welding nonferrous metals without heat or electricity, by cold pressure alone, was originally developed in England by General Electric Company, Ltd., and is being used there by a number of fabricators. It was introduced to American industry a little more than a year ago.

Requiring only the simplest tools and permitting the use of unskilled operators, this welding process has already evoked considerable interest throughout industry. The improved techniques further expand the field of application. One new development is for cold butt-welding of rods and wires such as aluminum-to-aluminum, aluminum-to-copper, and copper-to-copper. Tensile tests made in typical welded joints showed the failure occurred in the parent metal and not at the weld.

In the electrical industry a tack weld method was developed for making electrical connections and for attaching flat sheets or tubing to a rod. Laboratory and field tests have shown that the resistance weld is less than that of the original conductor.

Improvements have also been made in the manufacturing techniques for producing tubing from flat ribbon and sheet stock. The new tubing has smooth inside and outside surfaces, and can be drawn, bent, flared, and shaped.

Of special importance to the packaging industry is the improvement in the Koldwelding methods for joining thin sheets of aluminum, such as are used, for example, in collapsible tubes. The method effects a considerable saving of material, and the joint is leakproof. The Koldweld method of sealing such tubes prevents many of the leaks experienced with other methods of sealing, and withstands as much pressure as the seals obtained with the best previous methods.

TORSIONAL FATIGUE FAILURES

J. O. ALMEN

Research Laboratories Division, General Motors Corporation

Evaluation of the stresses and the fracture characteristics developed by torsional loads in parts made of metal. Torsional stress diagram is developed for the analysis of surface and sub-surface stresses. Evidence presented shows that the direct cause of fatigue failures from repeatedly applied torsional loads is always tensile stress; and the compressive stresses contribute only indirectly through altering the yield strength of the metal.

WHEN a twisting couple is applied to a uniform section specimen, such as a cylinder, every point on its surface is biaxially stressed. Tensile stresses act in the direction of 45 deg. helixes, and compressive stresses act in the direction of the opposite 45 deg. helixes. A third system of radial compressive stresses acts on sub-surface material. But the direct cause of fatigue failures from repeatedly applied torsional loads is always tensile stress, the compressive stresses contributing only indirectly through altering the yield strength of the metal.

The pattern of stresses in a specimen loaded in torsion is effectively shown in Fig. 1, in which it may be supposed that water is being pressed from a towel by the familiar process of wringing. In this analogy the stress acting in the direction of the woven stripes (left hand helix) is tension, and the stress acting perpendicular to the woven stripes (right hand helix) is compression. The radial compressive stresses are the result of tightening of successive layers on material beneath.

If the twisting couple is sufficiently increased, some of the threads that are loaded in tension will break and a tear will develop. The tear will, of course, extend in a direction normal to the tensile stress; that is, in the direction of a right hand helix. With continued growth the direction of the "crack" may change as the local direction of the applied force is altered by the extension of the tear. Because of the pronounced directional characteristics of the woven fabric, the twisted towel may not be acceptable as a specimen to demonstrate the nature of static failures in metals. It does, however, illustrate the orientation of the triaxial stresses and shows how static failures develop in this particular specimen.

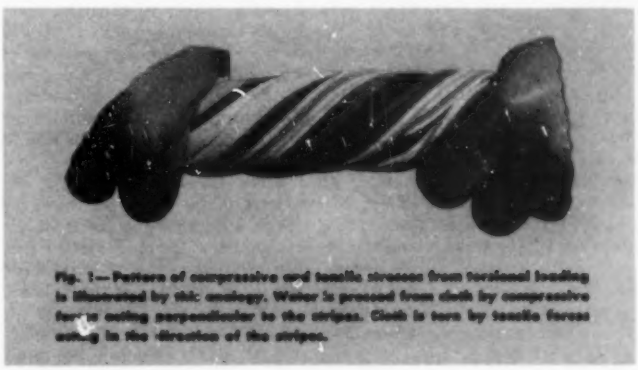


Fig. 1—Pattern of compressive and tensile stresses from torsional loading is illustrated by this analogy. Water is pressed from cloth by compressive force acting perpendicular to the stripes. Cloth is torn by tensile forces acting in the direction of the stripes.

Ductile Torsional Failures

When cylinders made of the usual metals of construction are statically loaded in torsion, the elastic surface stress pattern is the same as in the

Fig. 2—Torsional Failures—(A) Brittle fracture from tensile stress in a sheet of specially selected paper glued to a rubber cylinder.—(B) Ductile failure from compressive and tensile yielding in a cylinder of modeling clay.

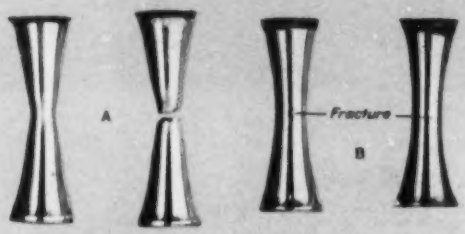


Fig. 3—Typical tensile stress fractures in specimens made of SAE 4340 of 32-36R, hardness.—(A) Necking and fracture due to static tensile loads.—(B) Fatigue fractures due to repetitive tensile loading.

towel but the characteristics of failure are not the same as noted in this simplified analogy.

Under static torsional loading of cylinders made from ductile materials, the fractures develop perpendicularly to the axis of the cylinder by transverse shear as is shown in Fig. 2 (*B*). This illustration shows a smooth cylinder of modeling clay that was twisted in the same direction as the towel shown in Fig. 1. It will be seen that the formation of the fracture was preceded by extensive plastic yielding. The tensile and compressive stresses contributed in substantially *equal* part to this plastic yielding, and failure occurred when the capacity of the material for plastic flow was exhausted. This is not difficult to visualize.

Since in static torsional tests of ductile materials the effect of the tensile stress component cannot be separated from the effect of the compressive stress component, it is convenient to treat them as a single new stress. A cylindrical bar statically loaded in torsion, therefore, is said to be stressed in transverse shear and longitudinal shear, each of which acts midway between the tensile and compressive stress components and 90 deg. to one another.

Brittle Fractures from Static Loads

When static torsional loads are applied to materials in which the effects of tensile and compressive stress components are *unequal*, the effects of the two components must be considered separately, because the characteristics of the resulting fracture will change from shear failure toward tensile failure as ductility is decreased.

In Fig. 2 (*A*) a rubber cylinder is shown on which is glued a sheet of specially selected paper. This paper is peculiar in that it has a minimum of directional properties; that is, its tear strength is substantially the same in any direction. A twisting couple of sufficient magnitude to tear the paper was applied to the rubber cylinder. Because of its low ductility, fractures occurred in the paper covering without visible evidence of plastic deformation; that is, the failures were brittle in character.

Since the rubber cylinder was twisted in the same direction as the towel, Fig. 1, the paper fractures are normal to the tensile stress components that caused the fractures. When the direction of the twisting couple is reversed, fractures in the paper covering the rubber cylinder will, of course, extend in the direction of a left hand helix.

Identical metal specimens that behave like ductile materials when fractured by a single load will behave like brittle materials when the fractures result from repeated loads. This phenomenon is true whether the specimens are loaded in torsion, in bending, or in tension, or by combinations of these.

This dual role is effectively demonstrated by the experiment recorded in Fig. 3. The two steel specimens at the left, Fig. 3 (*A*), have been subjected to static tensile loads of sufficient magnitude to cause plastic extension with the familiar reduction of area prior to fracture.

The two specimens at the right, Fig. 3 (*B*), also have been subjected to tensile loads. In these the calculated stress ranged from a minimum of 32,500 to a maximum of 150,000 psi. These loads were repeated a sufficient number of times on each specimen to develop the fatigue fractures shown in Fig. 3 (*B*). It will be seen that these fractures are brittle in character notwithstanding the fact that the specimens are identical in material, heat-treatment, dimensions, and workmanship with the two specimens shown in Fig. 3 (*A*), which necked severely.

In the foregoing demonstration tensile specimens are used, because their plastic deformations are more easily recognized than are the plastic deformations of equal or greater magnitudes that occur in metal cylinders loaded in torsion.

Fatigue Failures Are Brittle Failures

As was shown by the paper covered cylinder, Fig. 2 (*A*), brittle fractures develop from tensile stresses. Since torsional fatigue fractures, even in ductile metals, are "brittle" fractures, they also develop only from the tensile component of torsional loads. It is therefore necessary to abandon the shear stress convention when dealing with fatigue and other forms of failure in which, because of the manner of loading or because the materials are inherently brittle, fractures occur without appreciable ductility. Unless the shear stress convention is abandoned, one cannot understand the mechanism by which residual stresses increase or decrease fatigue or brittle static strengths, nor

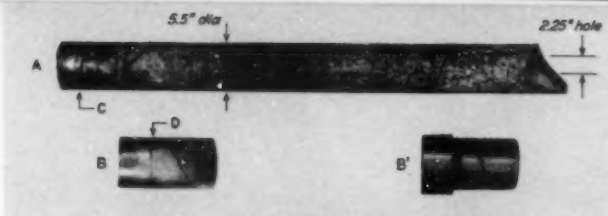


Fig. 4—Fatigue failures of hollow propeller shafts initiated at C and D by combined torsional and bending stresses aggravated by fretting corrosion.

can pre-stressing processes be applied to the best advantage.

The direction of torsional fatigue fractures will sometimes appear to deviate from a perpendicular to the principal applied tensile stress but, in the absence of seams or other major defects, deviations can usually be traced to residual stresses, surface stress raisers, or alterations in the stress pattern after a fatigue crack has begun to form.

Deviations from the latter cause sometimes occur in torsional specimens failing after relatively few stress cycles because the test stress is great and because, under repeated loads, plastic yielding occurs at stresses less than the static elastic limit. The extent of plastic yielding under repeated unidirectional loads varies with the magnitude of the dynamic stress and the duration of the load. Fractures in ductile fatigue specimens tested at high stress levels, therefore, may approach the characteristics of static torsional fractures.

In sound cylindrical torsional specimens free from residual stresses and severe stress raisers, tested by unidirectional load of such magnitude that failures occur after large numbers of stress cycles, the initial cracks are normal to the tensile stress components; that is, they extend in a direction approximately 45 deg. to the cylinder axis as occurred in the paper covered cylinder.

Fatigue Failures of Tubular Shafts

Portions of two marine propeller shafts 5.5 in. outside dia., which have centrally located longitudinal holes of 2.25 in. dia. are shown in Figs. 4(*A*), (*B*), and (*B*¹). Both shafts (not from the same boat) failed in normal service from fatigue fractures originating in fretted areas on the shafts. Fretting resulted from small amplitude rubbing of "pressed-on" bearing sleeves near the left (propeller) end of the shafts is shown by Fig. 4 (*B*¹), in which an artist has replaced the bearing sleeve that is missing in Fig. 4 (*B*). Minute relative motion between the bearing sleeves and the shafts in regions exposed to water caused deep pits, which formed a ring of severe stress raisers.

The combination of severe stress raisers, torsional propeller load, and superimposed bending stresses from off-center thrust of the propellers locally altered the direction of the principal tensile stress, as is indicated by the direction of the initial fractures at the left end of Figs. 4 (*A*) and (*B*). As the cracks progressed away from the fretted areas toward the right, their directions changed to approach normals to the directions of the torsional tensile stress, that is, they approach 45 deg helixes.

Since the shafts were tubular, and since the cracks progressed slowly, catastrophic failures did not develop immediately but long helical cracks formed instead.

Fractures Show Direction of Load

Note that the crack in Fig 4 (*A*) forms a left hand helix and that the crack in Fig. 4 (*B*) forms a right hand helix. Since torsional fatigue failures result only from the principal tensile stress, the direction of torsional loads causing fractures may be deduced by observing the direction of the fractures. It is thus apparent that the shaft of Fig. 4 (*A*) was loaded counter-clockwise as viewed from its ends, and that the shaft of Fig. 4 (*B*) was loaded in a clockwise direction. These deduced directions of loading were later verified from service records of the two shafts.

Coil Springs

Probably the most numerous of torsionally loaded machine elements are the familiar coil springs. The stress in the wire or bar from which coil springs are made is torsional whether the load is applied to extend or to compact the coils. The specimens *A* and *B* shown in Fig. 5 are one coil each of a conventional coil spring, which differ only in the direction of the applied load.

Specimen *A* is loaded in the direction to compress the coil as shown by the vertical load arrows. Under this load, the bar is twisted opposite to the twisting load that was applied to the towel, Fig. 1, and to the paper covered rubber cylinder, Fig. 2 (*A*). The tensile stress, therefore, is acting in the direction of a right hand helix as indicated by the stress arrows on the inner surface of the coil.

A fatigue fracture resulting from compacting loads on this spring would extend perpendicular to the tensile stress component in the direction of a left hand helix. As has been shown by Wahl (Ref. 1), the fracture would originate on the inner surface of the coil because of the greater stress in this region.

Specimen *B* is loaded in the direction to extend the coil. The tensile stress in this coil acts in the direction of a left hand helix and

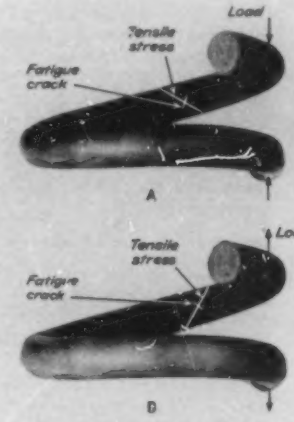


Fig. 5—Direction of tensile stress component and direction of resulting fatigue crack depend upon direction of applied load.

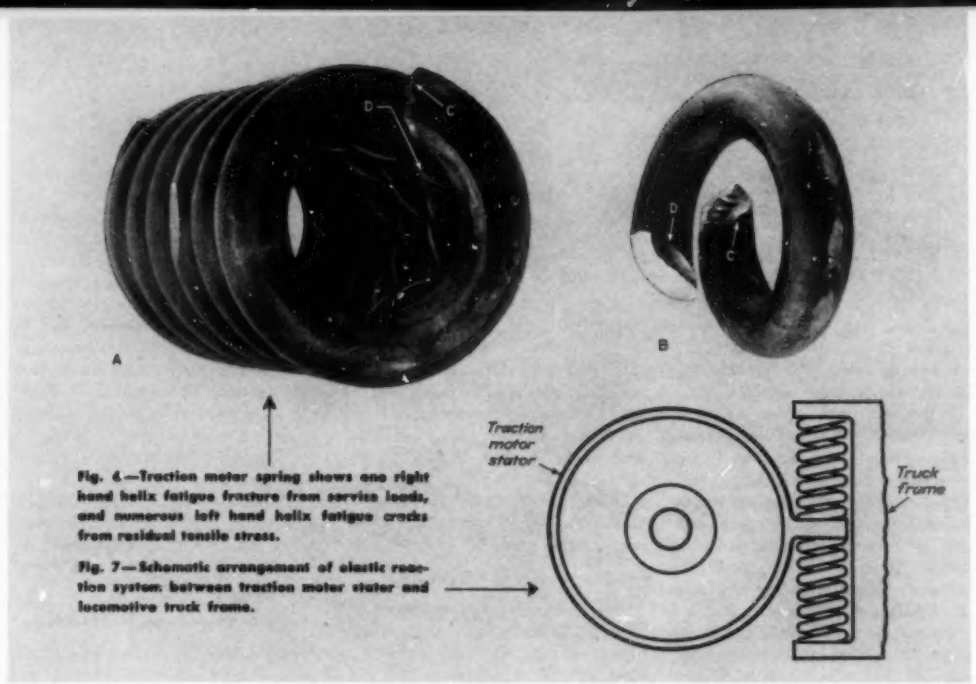


Fig. 6—Traction motor spring shows one right hand helix fatigue fracture from service loads, and numerous left hand helix fatigue cracks from residual tensile stress.

Fig. 7—Schematic arrangement of elastic reaction system between traction motor stator and locomotive truck frame.

any resulting fracture will develop in the direction of a right hand helix.

It follows that the direction of the load applied to a coil spring that has failed by fatigue can also be deduced by observing the direction of the fracture near its point of origin in relation to the direction of coiling. Note, for example, that the spring coils shown in Fig. 5 are wound as in left hand screw threads. Had they been formed as right hand screw threads, the directions of the tensile stress and therefore the directions of the fractures would have been reversed for the same directions of applied loads.

The ability to deduce the direction of the loads by observing the direction of fatigue fractures is often invaluable in discovering the cause or causes of failure, and in specifying materials and processing operations to prevent the recurrence of such failures.

Failures from Residual Stresses

The coil spring shown in Fig. 6 was part of the elastic reaction system between the traction motor stator and the truck frame of a diesel-electric locomotive. It was made from a hot rolled bar of AISI-1095 steel 13/16 in. nominal dia, which was hot wound in six coils having outer diameters of 3½ in. and inner diameters of 1⅞ in., heat-treated to a hardness of Rockwell C 45-47. Its purpose was to prevent the transmission of shock loads that result from rapid and violent changes in motor torque. A schematic sketch of the system is shown in Fig. 7, from which it is seen that the springs could be loaded only in the direction to compact the coils.

In Fig. 6 (*A*) is shown one complete fatigue fracture at *C*, originating on the inner diameter of the tapered end coil where the stress was locally aggravated by a severe stress raiser. Numerous non-fatal fatigue cracks as at *D* are also shown, which are made visible by magnetic particles as white diagonal lines on the inner diameters of most of the coils. More than 20 cracks, none of which developed to complete failure, could be counted in less than one-fifth of the total length of the coils.

In order that the characteristics of cracks and fractures could be more easily inspected, one coil was removed by grinding from the outer surface near the crack *D* as shown in Fig 6 (*B*). The complete fracture at *C* extends in the direction of a right hand helix originating in a sharp notch, apparently caused by the grip by which the bar was held during coiling; whereas each of the numerous cracks such as at *D* extend in the direction of left hand helixes, and have the origins in smooth surface metal.

Referring now to Fig. 5, and taking into account that these coils are wound in the opposite direction to the coils in the spring, Fig. 6, it is seen that the complete fracture at *C* is normal, being caused by the tensile stress component of the applied load.

Abnormal Fatigue Cracks

The multiplicity of cracks as at *D* are however abnormal because:
(a) They *appear* to have been caused by the compressive stress component of the applied load, and
(b) Many large cracks were formed but none propagated through the bar to complete failure.

Since fatigue cracks cannot develop from compressive stresses, the numerous cracks must have been caused by tensile stresses such as would result from extending the coils. It was not possible, however, to apply extension loads to this spring through the mechanism of the elastic system shown in Fig. 7. It was, therefore, tentatively assumed that the cracks were caused by the following:
(c) Rebound inertia loads extend-

ing the spring upon sudden reversal of torque, or

(d) Tensile components of residual stresses that were induced during processing, or

(e) A combination of the rebound inertia loads and tensile components of stresses induced during processing, (c) and (d).

Through correspondence with the manufacturer, it was learned that these springs were processed in such manner as to develop residual tensile stress normal to the direction of the fatigue cracks. The stress was developed by repeatedly overloading the springs in the direction of normal service loads sufficiently to develop permanant set. This process is extensively used by spring makers and is variously known as pre-setting, prestressing, bulldozing, and scragging. As applied to the spring shown in Fig. 6, the overloading produced a permanent set of $\frac{3}{16}$ in. in its free height.

Further discussions of the abnormal fatigue cracks in the spring, Fig. 6, will be deferred until a diagram capable of representing their causes is described.

Torsional Stress Diagrams

The two conventions now used to represent torsional stresses are not suitable for torsional fatigue studies because:

(a) The strain rosette indicates only surface strain without regard to sign, and

(b) Section diagrams show only transverse shear.

For torsional fatigue studies, it is necessary to use a diagram that is capable of showing separately the magnitudes and distribution of biaxial tensile and compressive stress components extending from the surfaces of torsion specimens to their neutral axes. A torsional stress diagram suitable for this purpose has been developed. It is similar to the conventional diagrams used to illustrate stress distribution through specimens loaded in bending and in direct tension or compression.

A plane intersecting a cylinder at an angle of 45 deg. is shown in Fig. 8. The width of the plane OO' is equal to and coincident with the diametral line OO' of the cylinder. The axis XX' of the cylinder and WW' of the plane intersect the diametral line OO' at O''. The angle $XO''W$ is equal to 45 degrees.

When a twisting couple is applied to the cylinder, the tangential stresses through the specimen acting along either 45 deg. helix are assumed to increase in proportion to the radial distance from the XX' axis, where they are zero to maximums at the cylinder surface. Under a clockwise twisting couple, as indicated by the arrows on the cylinder, compressive stresses normal to the radial line OO'' act in the direction of right hand helixes and lie in the plane $WPTW'$. *Tensile* stresses normal to the radial line $O''O'$ act in the direction of left hand helixes and lie in the $WRLW'$ plane.

In the diagram, compressive stresses will be shown to the right of the diametral line OO' in the plane $OTLO'$, and tensile stresses will be shown to the left in the plane $OPRO'$. With this diagram, the nominal tensile and compressive stress components from a twisting couple

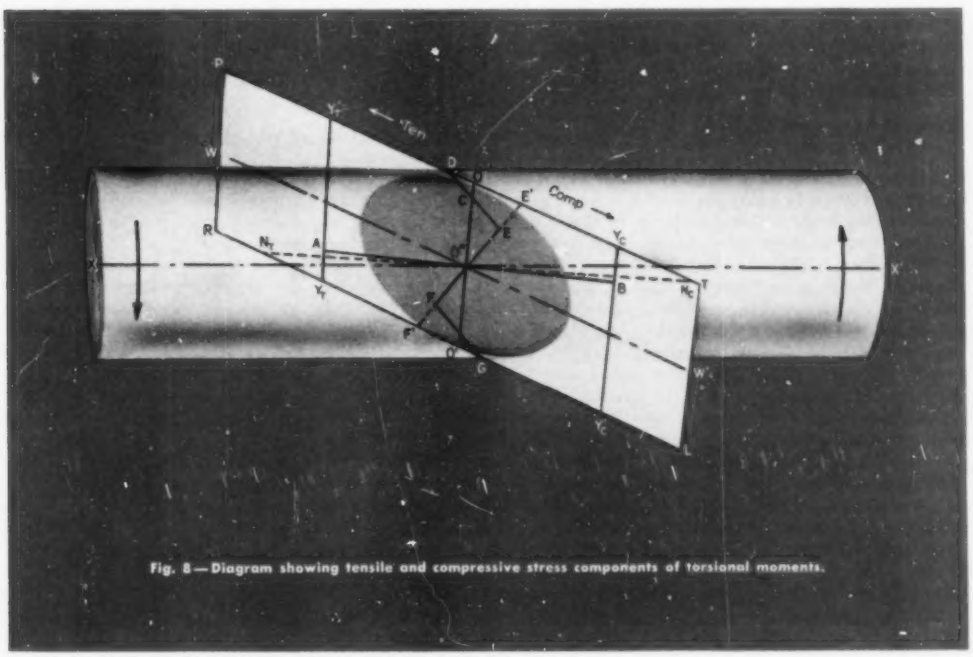


Fig. 8—Diagram showing tensile and compressive stress components of torsional moments.

may be expressed by the straight line N_cN_c in the plane $PTLR$ passing through the point O''. The stress at any depth within the cylinder is indicated by the perpendicular distance from the diametral line OO' to the nominal stress line shown on the diagram.

Stresses Are Biaxial

For straight cylindrical specimens loaded in pure torsion, the stresses at opposite ends of a diameter are correctly expressed in direction, sign and magnitude by the diagram because the stresses are symmetrically distributed with respect to the cylinder axis. In practice, however, few specimens are loaded in pure torsion, therefore, the stress patterns are variously distorted. The stresses at opposite ends of a diameter may not be identical and the neutral axes may not coincide with the specimen axis.

Since the diagram of Fig. 8 is designed to express biaxial stresses, it must always be remembered that the points O and O' actually represent a single point on the cylinder surface. The plane $WRLW'$ is in reality at a right angle to the plane $WPTW'$, as will be evident if the plane $WRLW'$ is rotated 180 deg. on the cylinder axis XX', at which time the radii OO'' and $O'O''$ will coincide. The arrangement shown in Fig. 8 is used as a means of simplifying the diagram.

Prestressing Induced by Torsional Overload

In the plane $PTLR$ of Fig. 8 is shown a diagonal line $N_cO''N_c$. This line represents the nominal tensile and compressive stress components acting normal to the diametral line OO' as a result of a clockwise torsional couple applied to the cylinder. The portion N_cO'', acting in the direction of a right hand helix, represents the range of compressive stress from zero at the point O'' on the cylinder axis to a maximum of ON_c at its surface. The portion N_cO'', acting in the direction of a left hand helix, represents the range of tensile stress from a value of zero at O'' on the cylinder axis to $O'N_t$ at its surface.

The compressive yield stress of the cylinder material is represented as the distance from the diametral line OO' to the parallel line Y_cY_c'. Likewise, the tensile yield stress is the distance from OO' to the tensile yield line Y_tY_t'. It is seen that the nominal stress N_cN_t from the applied torsional couple exceeds the surface compressive and tensile yield strengths by the quantities Y_cN_c and Y_tN_t respectively.

The triangular areas N_tY_tA and N_cY_cB represent material that was plastically deformed by yielding, the actual stress is therefore represented by the line Y_tABY_c. Note that to avoid unnecessary complications in this diagram any change in yield strength that may have resulted from the cold working during plastic yielding is neglected.

Upon release of the external twisting couple, elastic recovery returned the spring to its original state except for the permanent set that resulted from the residual stresses induced by plastic yielding. Elastic recovery necessarily proceeded until a state of equilibrium was attained between the clockwise and counter-clockwise twisting moments. This condition is indicated by the zig-zag line $DEFG$. Since the specimen, Fig. 8, is a straight round bar loaded in pure torsion, equilibrium is attained when the clockwise torsional moments represented by the area ODC and the counter-clockwise moments represented by the area CEO'' are equal.

Residual Stress From Plastic Yielding

If no permanent set has occurred, the line EF would coincide with line OO' when the external twisting couple was removed. The deviation of the line EF, therefore, may be used as a measure of the permanent set. Permanent set is equal to the angle imparted to the specimen by an external twisting couple that will biaxially stress a point on the cylinder surface with the compressive component OE'' and the tensile component $O'F''$.

Stresses represented by OD and $O'G$ are the biaxial residual stresses that were developed at any point on the surface of the specimen as a result of plastic yielding. Compressive yielding equal to Y_cN_c resulted in tensile residual stress equal to OD. Tensile yielding equal to Y_tN_t resulted in compressive residual stress equal to $O'G$. Note that these residual stresses are opposite in sign to the respective stresses that were applied by the external twisting couple, and that they are greatest when the externally applied load is at its minimum.

Fatigue From Residual Tensile Stress

In many cases, the residual tensile stress OD becomes great enough to initiate fatigue cracks. Such cracks grow more slowly than cracks that are initiated by external loads because the stress decreases with depth until, at a depth somewhat less than is represented by OC, their inward progress is stopped by insufficient tensile stress or by encountering compressively stressed material.

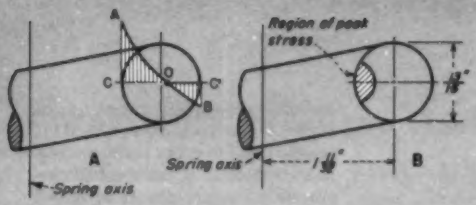
While the torsional stress diagram is identical in form with stress diagrams representing beams loaded in bending, it must be remembered that the torsional diagram represents the two components of biaxial stresses normal to a common radius; whereas the bending stress diagram represents stresses in a beam on opposite sides of the neutral plane.

Although the torsional diagrams that follow will not include the cylinder shown in Fig. 8, the ellipse of intersection may be retained as a mark of identification to distinguish between bending stress diagrams and torsional stress diagrams.

Cause of Abnormal Fatigue Cracks

Returning now to the coil spring, Fig. 6, it will be recalled that, considering only the nominal stress in the spring, the numerous abnormal cracks as at D appear to have been caused by compressive stresses. But since compressive fatigue cracks are impossible, it became necessary to discover sources of tensile stresses acting in the direction of nominal compressive stresses of sufficient magnitude to produce the observed cracks.

During the discussion of the biaxial torsional stress diagram, Fig. 8, it was shown that, qualitatively, the required residual tensile stress OD was developed as a result of the plastic yielding that occurred upon the application of the overload N_cN_t. A similar diagram representing the residual stresses from overloading the spring, Fig. 6, would be expected to supply even more interesting information.



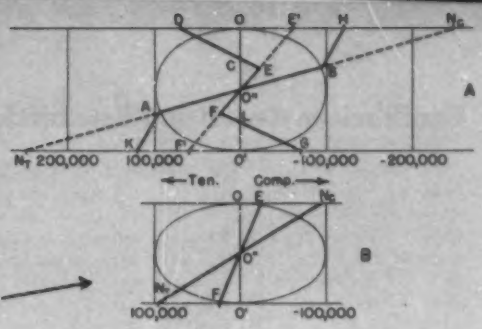


Fig. 9—Unfavorable spring index greatly increases stress in region of inner diameter of coils.

Fig. 10—Approximate stresses in springs based on hardness of steel, prestressing method, spring index, and type of fracture.

Reconstruction of Residual Stresses

Although dissection stress analysis of this spring has not been made, and little is known regarding the magnitude of the processing overload stresses, or the stresses that resulted from service loads, it is nevertheless possible to reconstruct the residual stresses with sufficient accuracy to show the cause of the abnormal fatigue cracks.

From the hardness of the steel its yield stress may be estimated; from the dimensions of the spring and the measured depth of the fatigue crack at *D*, Fig. 6 (*B*) the depth of the residual tensile stress can be judged; and from the character of the mechanism in which it was used it can be appreciated that inertia extension loads were possible.

The pre-setting operation was stated by the manufacturer to have reduced the free height of the spring 3/16 in. To understand how so small a permanent set could result in large residual stresses, it will be necessary to consider the effects of spring dimensions on the magnitudes and distribution of stresses in this particular spring.

Effects of Low Spring Index on Stress Distribution

The diagrams Figs. 9 (*A*) and (*B*) have been prepared in accordance with the theories and test data of Wahl (Ref. 1) to show the distribution of stresses in the elastic range along a transverse diameter of the steel bar forming the spring, Fig. 6. In Fig. 9 (*A*), it is seen that the stress *CA* on the inner diameter of the coils exceeds the stress *C'B* on the outer diameter by more than 2.5 to 1. Note also that the point *O* of zero stress lies a considerable distance outside the center of the bar.

In diagram Fig. 9 (*B*) is shown that the peak stress is concentrated in a relatively small area near the inner circumferences of the coils. This unfavorable stress distribution results from the forming of proportionately small diameter coils from a bar of large diameter, that is, a spring having the very low index of 3.5.

Applying the torsional stresses shown in the conventional transverse shear stress diagram Fig. 9 (*A*) to biaxial torsional diagrams of the type described in Fig. 8, the diagrams Figs. 10 (*A*) and (*B*) are obtained. These diagrams show, in biaxial terms, the same stress relationships that are represented in Fig. 9 (*A*). Fig. 10 (*A*) presents the greater stress range of Fig. 9 (*A*) from the neutral axis at *O* to the inner diameter of the coil at *C*, and Fig. 10 (*B*) presents the lesser stresses in Fig. 9 (*A*) from the neutral axis at *O* to the outer surface *C'* of the coil.

The nominal biaxial pre-setting stress on the inner diameter of a coil is approximated in Fig. 10 (*A*) by the diagonal line N_1N_2, of which $O''N_2$ represents the compressive stress component ranging from zero at the neutral axis to a maximum of 250,000 psi at the surface, and $O''N_1$ represents the tensile stress component through the same range.

Yield Stress Estimated From Hardness of Specimen

Tests showed that, below a decarburized layer, the steel ranged in hardness from 45 to 47 Rockwell C, from which it was estimated that the initial tensile and compressive yield stress was 95,000 psi as is indicated at *A* and *B*. These yield stresses are assumed to increase to 120,000 psi at the surface along the lines *AK* and *BH* as a result of cold working during extensive plastic yielding. By these assumptions the broken line *KABH* represents the actual stresses from the pre-setting overload.

Upon release of the external load, elastic recovery returned the spring to its original height except for the 3/16 in. permanent set that resulted from plastic yielding. The magnitude and depth of plastic yielding is indicated by the triangular areas N_2HB and N_1KA which, respectively, represent compressive and tensile yielding. It will be understood that, because of the distorted stress pattern shown in Fig. 9 (*A*), the magnitude and depth of plastic yielding varied continuously around the circumference of the bar from a maximum, as shown in Fig. 10 (*A*), to no yielding at all for the diametrically opposite location represented in Fig. 10 (*B*).

In the straight cylindrical specimen represented by the diagram Fig. 8, equilibrium conditions were satisfied when the sum of the clockwise and counter-clockwise torsional moments represented in the single diagram were equal to zero.

It is not possible, however, to represent in any single diagram the residual stresses in a coil spring or other specimen in which the stresses are not symmetrically distributed. In such specimens, integration of positive and negative moments of a section is necessary to represent its precise equilibrium conditions. In view of the nature of the present problem, however, estimates of residual stress magnitudes from the two diagrams (*A*) and (*B*) of Fig. 10 will be sufficiently accurate for all practical purposes. This figure will be discussed further.

Equilibrium Condition Established

As previously stated, the diagram Fig. 10 (*B*) represents the biaxial stresses in the opposite side of the spring bar from the stresses shown in Fig. 10 (*A*). Since the latter stress is more than 2.5 times as great as the former, the applied stress N_1N_c of Fig. 10 (*B*) does not exceed the yield stress of the metal at any point.

Equilibrium in the free spring is assumed to be established when the clockwise torsional moments, represented by the residual stress areas *CEO"* and *LFO"* of Fig. 10 (*A*) plus the areas *OEO"* and *O'FO"* of Fig. 10 (*B*), are equal to the counterclockwise torsional moments, represented by the areas *OCD* and *O'GL* of Fig. 10 (*A*). By inspection these conditions are estimated to be satisfied by the residual stresses shown in the diagrams (*A*) and (*B*) of Fig. 10.

Mention has been made of a decarburized layer on the surface of the spring, the hardness of which was measured as low as Rockwell C 35. To indicate other effects than relative weakness of this soft layer, the diagram Fig. 11 (*A*) has been prepared. This diagram is the same as that of Fig. 10 (*A*) except that the yield stress of the surface is reduced to correspond to its measured hardness. It is seen that compressive and tensile yield strengths of the cold worked metal are reduced by an estimated 40,000 psi from *OH* and *O'K* to *OH'* and *O'K'*.

Decarburization Increased Residual Stress

Upon release of the external load, the added yielding appears as increased biaxial residual stresses *GG'* and *DD'*. These, like the previously described residual stresses in the metal near the inner diameter of the coils, are of opposite sign to the nominal biaxial stresses from the applied load.

With the added surface yielding, the residual stresses are represented in the diagram Fig. 11 (*A*) by the broken line *G'GFEDD'*. The yield stress of the carburized surface after cold working, however, was estimated to be 80,000 psi, which establishes this value as a limit of residual stress magnitude.

Much of the added surface residual stress shown in Fig. 11 (*A*) is therefore lost when the spring is unloaded, and the residual stress appears as the broken line *G'GFEDD'* in the diagram Fig.11 (*B*). This diagram is a representation of the probable stress range experienced by the spring, Fig. 6. In designing the spring the manufacturer calculated, by the Wahl formula (Ref. 1), that the load applied in service would stress the inner surface of the coils slightly less than 100,000 psi. The dashed diagonal line N_1N_c, Fig. 11 (*B*), therefore represents the calculated nominal service stress. The actual applied stress, which is represented by the broken line *K'KABHH'*, of course, is the algebraic sum of the nominal service stress and the residual stress.

Actual Stress Range Opposite to Nominal Stress Range

The stress range for both stress components is indicated by horizontal lines between the residual and the applied stresses of Fig. 11 (*B*). These show that the surface stress in the direction of the nominal compressive component ranged from 20,000 psi compression to 80,000 psi tension; and that the surface stress in the direction of the nominal tensile component ranged from 20,000 psi tension to 80,000 psi compression. This condition is seen to be almost a complete reversal from the nominal stresses in the extra vulnerable (Ref. 2) surface metal.

In addition to the stresses accounted for in the diagram, Fig. 11 (*B*), are possible biaxial stresses from rebound inertia when the applied load was suddenly released. The inclusion of such stresses up to 20,000 psi would not alter the magnitude of the surface stresses as represented in the diagram. They would only replace the remaining residual stresses from surface yielding *DD'* and *GG'*, which would be dissipated in the process.

From the foregoing it is seen that the numerous cracks on the inner surface of the coil spring, Fig. 6, which by superficial inspection appeared to have been caused by the compressive stress component of torsional loads, are in fact normal tensile fatigue failures. They demonstrate again that fatigue failures are tensile failures.

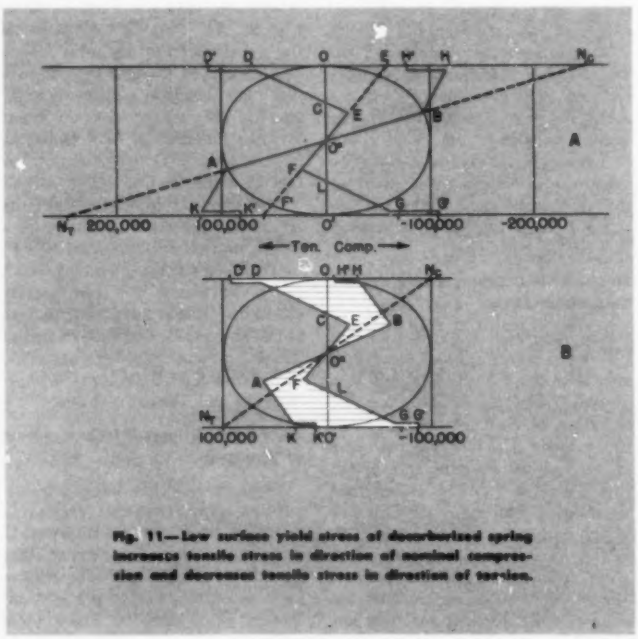


Fig. 11—Low surface yield stress of decarburized spring increases tensile stress in direction of nominal compression and decreases tensile stress in direction of torsion.

Development of Fatigue Cracks

Having demonstrated that the numerous "compressive" fatigue cracks are actually tensile failures, it remains to show why so many non-fatal cracks formed in a single specimen, since it is usually found that a single crack grows to complete failure before another forms.

The numerous fatigue cracks developed because the depth of each crack was limitd by underlying compressively stressed metal. Referring to Fig. 11 (*B*), it is seen that the residual tensile stress that was responsible for the cracks is enclosed in the triangle *OD'C*. Each crack originated at the surface from the tensile stress *OD'*. As the depth of a crack increased, the tensile stress decreased until at *C* further progress is stopped because the stress, normal to the crack, became compressive (Ref. 3).

Since the tensile stress decreased with depth, the cracks advanced at a decreasing rate. Their progress presumably stopped shortly before reaching the point *C*, unless rebound inertia was great enough to momentarily increase the depth of the tensile stress and thus depress this point. Evidence of slow growth is seen in the smooth surfaces of such residual stress cracks, one of which is exposed at *D*, Fig. 6 (*B*).

The depth of the crack at *D* supplies a means of checking the accuracy of the assumptions made in constructing the diagrams Figs. 10 and 11, because the crack depth should correspond to the depth of the residual tensile stress *OC* in these diagrams.

The measured depth of the crack was 0.24 in., and the measured radius of the spring bar was 0.401 in. but, as shown in Fig. 9 (*A*), the distance from the surface at *O* to the neutral axis at *O''*, under stresses within the elastic range, is greater than the radius of the bar by approximately 0.06 in. The depth of the neutral axis *OO''* in Fig. 9 (*A*), therefore, may tentatively be taken as 0.46 inch.

The metal on the inner surface of the spring, however, experienced extensive plastic yielding during the pre-setting operation, as shown in Fig. 10 (*A*), the distance from the surface to the neutral axis was further increased to perhaps as much as 0.5 in. The depth of the residual stress *OC*, Fig. 11 (*B*), should be in nearly the same ratio to *OO''* of the same diagram as the measured crack depth is to the depth of the neutral axis, that is, *OC/OO''* is approximately equal to 0.24/0.5. With or without allowance for inertia stresses the agreement is seen to be very good.

Crack Growth Rapid

The behavior of fatigue cracks originating from the externally applied tensile stress is very different from the residual tensile stresses that have been discussed. Consider the tensile stress component of the external load in either diagram of Fig. 11. Assume a crack to be initiated by the tensile stress *O'K'*. As the crack depth increases, the tensile stress increases because the same external load must be supported by a decreasing area of metal. The rate of growth is therefore increased with crack depth and complete failure follows so quickly that rarely does a second crack have time to form.

Evidence of the increasing rate of growth of the fatigue fracture caused by externally applied tensile stress at *C*, Fig. 6 (*B*), is seen by the increasing roughness as this catastrophic crack advanced.

The presence of one or several cracks normal to the nominal compressive component did not greatly alter the functioning of the spring, Fig. 6, because the externally applied load acted to close the gaps and its behavior under load remained nearly normal. Continued operation initiated additional cracks that appeared at regularly spaced intervals, because as each crack formed the residual tensile stress was reduced for a distance on either side, and a new crack could not form in the stress relieved metal.

As each crack was formed the free height of the spring increased slightly because some of the residual stress that contributed to its permanent set was removed.

Moderate Versus Severe Pre-Setting

In Figs. 9 and 11, it has been seen that the numerous pseudo-compressive fatigue cracks in the spring, Fig. 6, were caused by residual tensile stresses that developed from excessive local plastic yielding during pre-setting. Although, under unidirectional loads such cracks seldom propagate to complete failure, it is nevertheless important to show the more desirable effects of moderate pre-setting in springs of high index. For this purpose, assume a spring similar in every respect to the spring diagrammed in Fig. 11 (*A*) except that the maximum nominal pre-setting stress is reduced from 250,000 psi of the former to 140,000 psi, as is shown by the diagonal line N_1N_2 of Fig. 12 (*A*).

Note that the actual applied surface compressive stress *OH'* and tensile stress *O'K'* are only slightly reduced from the corresponding stresses in Fig. 11 (*A*) but the permanent set, which is measured by *OE'' and O'F''* in the respective diagrams, is greatly reduced. The lower permanent set has the effect of reducing the corresponding nominal residual stresses *OD'* and *O'G'* from the nominal value of 110,000 psi in the more severely processed spring to 54,000 psi in the moderately pre-set spring.

Under the same unidirectional operating loads that were applied to the severely pre-set spring, Fig. 11 (*B*), in which the maximum residual tensile stress *OD'* is seen to be reduced from 110,000 to 80,000 psi by local yielding, the equivalent stress in the milder pre-set spring Fig. 12 (*B*) is only 54,000 psi.

The corresponding surface tensile stress *O'K'* in the direction of the nominal tensile component of the applied load is seen to have increased from 20,000 psi in Fig. 11 (*B*) to 46,000 psi in Fig. 12 (*B*). It is, of course, possible to select a pre-setting load that will, under the nominal unidirectional test load of 100,000 psi, produce residual tensile stress equal to the actual applied tensile stress, in which case each would be 50,000 psi.

Since fatigue cracks originating from applied tensile stresses quickly grow to catastrophic proportions, whereas cracks from residual tensile stresses are relatively harmless, it is advantageous to reduce the former stress at the expense of the latter, as shown in Fig. 12 (*B*). In the diagrams Figs. 11 (*B*) and 12 (*B*),

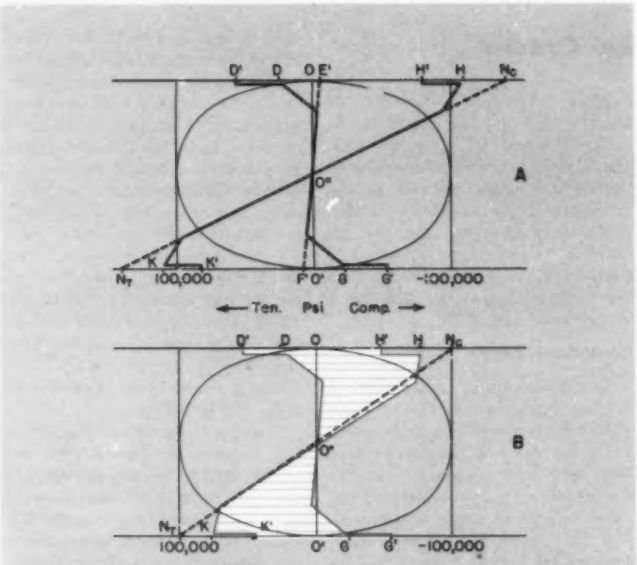


Fig. 12—Properly applied torsional prestressing reduces resultant tensile stress in spring and greatly increases their fatigue strength under unidirectional loads.

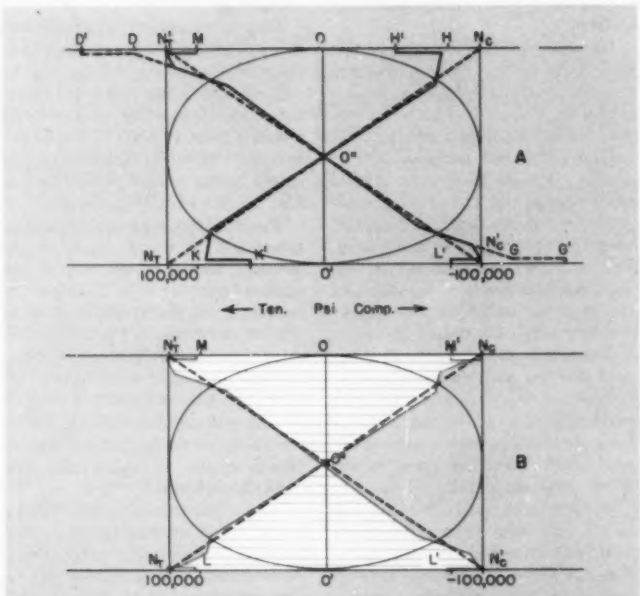


Fig. 13—Torsional prestressing is ineffective or harmful to fatigue strength of springs subjected to repeated reversed loads.

the operating stress ranges acting in the directions of both right and left hand helixes throughout the specimens are also compared.

Note in both Figs. 11 (*B*) and 12 (*B*), that the lower yield strength of the soft decarburized layers decreased the magnitudes of the dangerous tensile stress components from externally applied unidirectional loads by the amounts *KK'*. It is not known whether this stress reduction is sufficient to compensate for the lower fatigue strength of the decarburized steel, but the ill effects of decarburization are at least diminished.

Pre-Setting May Be Ineffective

Under reverse loading, whether the specimen is loaded in torsion or bending, this compensation cannot function because pre-setting in one direction will only increase the harmful stresses when the load is reversed. This qualification, as is shown in the diagrams Fig. 13, demonstrates again the fallacy of measuring fatigue strength by arbitrary test procedures and accounts for much confused thinking regarding fatigue of metals.

Assume a spring identical with the spring described in the discussion of Fig. 12 including the presetting operation; the only difference being that instead of unidirectional loading the applied loads will be repeatedly reversed.

After the prestressing operation the first load applies the nominal stress N_cN_t, which produces the actual stress $H'HKK'$ as shown in Fig. 13 (*A*). These stresses are seen to be identical with the corresponding stresses in Fig. 12 (*B*), since in both diagrams the loads applied to this point have been alike.

When the load is reversed, the nominal applied stress is that which is indicated by the dashed diagonal $N'_cN'_t$ of Fig. 13 (*A*). Except for plastic yielding, the change in actual stress will of course be equal to the change in nominal stress as is indicated by the broken line *D'DGG'*. But since this change exceeds the yield stress of the decarburized layer by the amounts *D'M* and *G'L'*, and of the harder underlying steel by the amounts DN'_t and GN'_c, plastic adjustment must occur by which the actual stress becomes MN'_t N'_cL'.

After a few reversals the operating stress range will be approximately that which is shown by the horizontal lines in Fig. 13 (*B*). This stress range is seen to approximate the range of the nominal applied stress, as indicated by the dashed line, except for repeated plastic yielding of the decarburized layer.

Yielding occurs with each load reversal because the applied surface stress ranges from plus 100,000 psi to minus 100,000 psi, but the yield strength of the decarburized layer is 80,000 psi in either direction. Plastic yielding of the decarburized layer must therefore occur with each load reversal as indicated by the stresses $N'M$, N_1M', N_1L, and $N'L'$ of Fig. 13 (*B*) unless the applied nominal stress is reduced to 80,000 psi or less.

A comparison of the tensile stress magnitudes in Figs. 12 (*B*) and 13 (*B*) shows why fatigue strength is greater under unidirectional loads than under reversed loads as is empirically expressed by diagrams of the Goodman type. It will also show why some experimenters find prestressing treatments of little or no value, while others find such operations indispensable.

Railway Spring Failures

Fatigue failures of coil springs having fractures normal to the nominal tensile stress component, and pseudo-compressive fatigue cracks extending in the direction of the opposite helix as shown in Fig. 6, frequently occur in railway equipment. Since the pseudo-compressive cracks rarely develop to complete fracture, they are seldom discovered because usually they can be detected only by magnetic or black light inspection of springs after considerable service use.

The short section of a coil spring shown in Fig. 14 was cut from a railway car suspension spring, which had been removed because of the catastrophic fatigue fracture originating on the inner surface of a coil, as is shown at the left of the portion *A*. Although there was no reason to suspect additional cracks, the spring, which was donated to the author's "scrap pile" by a railway repair yard, was subjected to magnetic particle inspection. This inspection quickly disclosed a short "compressive" crack, also on the inner surface of the coil, a short distance from the normal catastrophic fracture.

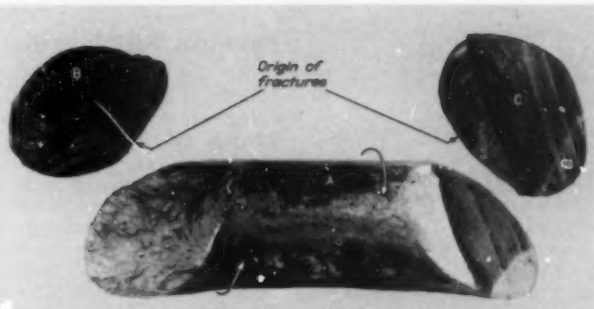


Fig. 14—Fatigue failures of coil springs. Note opposite diagonals of fractures from (B) tensile stress and from (C) "compressive" stress.

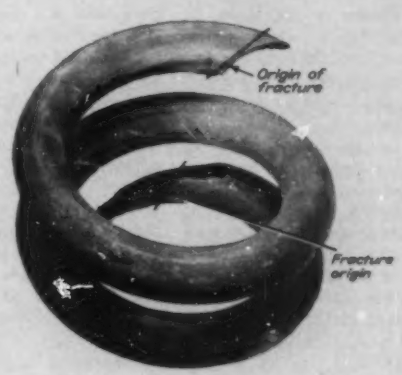


Fig. 15—Experimental locomotive suspension spring shows two left hand helix fatigue fractures from service loads and several right hand helix fatigue cracks from residual tensile stress.

To disclose the dimensions of the crack, a grinding cut was made from the opposite side of the bar near the plane of the crack and the remaining section was broken, as shown at the right of the portion *A*. Photograph *C* of Fig. 14 was made normal to the plane of grinding to better show the characteristics of the pseudo-compressive crack. The well defined "fish scale" markings show that the crack advanced slowly from the inner surface of the coil to its final depth, which was found to be one-sixth the diameter of the bar.

Since this crack was caused by residual tensile stress, it may be concluded that its depth represents the approximate depth of the residual tensile stress, and that its further progress was stopped by underlying compressive stress, as is shown at *C* in the diagrams of Figs. 11 (*A*) and (*B*). No doubt this crack had reached its final depth long before the catastrophic crack commenced.

The photograph *B*, Fig. 14, shows details of the normal fracture that was caused by the tensile stress component of the externally applied load. The absence of well defined

"fish scale" markings shows that the initial crack propagated quickly to complete failure with relatively few load applications.

Residual Stress From Service Loads

Specification for material, heat-treatment and processing are not available but it is doubtful that this spring was intentionally pre-set. It was made from a bar 1.3 in. dia., hot wound in coils 5.55 in. outside diameter, or a mean coil diameter of 4.25 in. The spring index, that is, the mean coil diameter divided by the bar diameter, was 4.25/1.3 or 3.27. This ratio is even more severe than that of the spring shown in Fig. 6, the index of which was 3.4. Nominal stress distribution, therefore, was similar to that shown in the diagram Fig. 9 (*A*) by which it was found that the stress on the inner surface of the coils was 2.5 times as great as the stress on the outer surface.

Sub-surface hardness was found to be Rockwell C 44-45, and the hardness of a decarburized surface layer to range from Rockwell C 25 to 35. Residual tensile stresses of sufficient magnitude to initiate a fatigue crack, and of sufficient depth to correspond to the depth of the pseudo-compressive crack shown in Fig. 14 (*C*), could develop from a few applications of overload in normal service.

An experimental railway suspension spring is shown in Fig. 15, which has two left hand helix fatigue fractures normal to the tensile stress components of the applied service load, and several right hand helix pseudo-compressive fatigue cracks normal to the nominal compressive stress components. This spring was hot formed from a bar of 15/16 in. dia. into coils of 5⅝ in. outside diameter. Its index was 5. Sub-surface hardness was found to be Rockwell C 47-49, and the decarburized surface hardness to be Rockell 33-35. The depth of the non-fatal crack at the right was 0.16 in. This specimen presents no unusual characteristics. It is shown only as additional evidence that torsional fatigue failures are tensile failures. Another interesting vehicular spring type consisting of straight steel bars loaded in torsion is sometimes used in place of coil or leaf springs, and is discussed in the next

Torsion Bar Springs

In Fig. 16 is shown a torsion bar spring extensively used in World War II in the suspension system of a military vehicle.

This spring is shown as it appeared after having been laboratory fatigue tested to failure by unidirectional loads applied in a clockwise direction. The reader can readily confirm the direction of the applied loads by noting the direction of the fracture at its point of origin. Since the fracture was caused by the tensile component of the applied loads it is seen that, just as in the case of the paper covered cylinder shown in Fig. 2 (*A*), the loads must have been in a clockwise direction.

These torsion bars were provided with splined enlargements 2.75 in. at each end, whereby the vehicle load was transferred from the track wheels through the elastic bars to their respective anchorages on the opposite side of the vehicle. The diameters of the effective elastic portions of the bars were 2.27 in. and their effective lengths between enlargements were approximately 72.7 in. They were made of NE9262 steel, heat-treated to uniform hardness of Rockwell C 49-50 through their sections. Surface decarburization was too shallow to be detected by indentation hardness measurements.

Prestressing Increases Strength

For the purpose of further increasing the compactness of this suspension system the torsion bars were, as final operations, prestressed by shot peening and by overloading (pre-setting) in the direction of the normal service load.

In a previous report concerning the same torsion bars, H. O. Fuchs and R. L. Mattson (Ref. 4) state that these pre-setting operations had the effect of increasing the initial yield strength of the bars from 115,000 to well over 140,000 psi with a correspondinng increase in their fatigue strengths. They also stated that: "The practical importance of raising the safe load stress from about 105,000 to 140,000 psi may be readily appreciated. Since space and weight requirements are inversely proportional to the square of the safe load stress, it amounts to saving almost half the space and weight which should be necessary without pre-setting."

The sequence in which the prestressing operations were applied was important, as is shown by the bar chart Fig. 17, which is re-plotted from a report issued by the National Defense Committee of the O.S.R.D. (Ref. 5). It is seen that the fatigue strength was much greater in torsion bars that were shot peened before pre-setting than when the opposite sequence was followed or when shot peening was omitted. Shot peening before pre-setting was more effective, presumably because it reduced the damage to the surface metal that would result from extensive tensile plastic yielding.

The pre-setting operations were performed by applying, through the splined ends, five successive torsional loads sufficient to twist the finished bars to the same end position of approximately ninety degrees from the original free position. In terms of nominal stress this twist was approximately 255,000 psi, which greatly exceeded the yield strength of the bars. As a consequence of extensive plastic yielding each bar developed a large permanent set.

Damage by Tensile Yielding

Since the hardness of the bars was Rockwell C 49-50 and their ductility correspondingly low, it is believed that the capacity of the unpeened vulnerable surface metal for tensile plastic adjusment was therefore reduced.

When shot peening preceded the pre-setting operation, the vulnerable surface became biaxially stressed in compression by an amount approximating one half of the yield strength of the steel. As a result of this residual compressive stress, no tensile plastic yielding occurred in the vulnerable surface and much or all fatigue damage was thereby avoided.

Shot peening did not alter the extent of tensile plastic yielding a short distance below the surfaces of the bars, but since sub-surface metal is apparently less vulnerable to damage by tensile plastic yielding than surface metal the loss of fatigue strength, if any, was small.

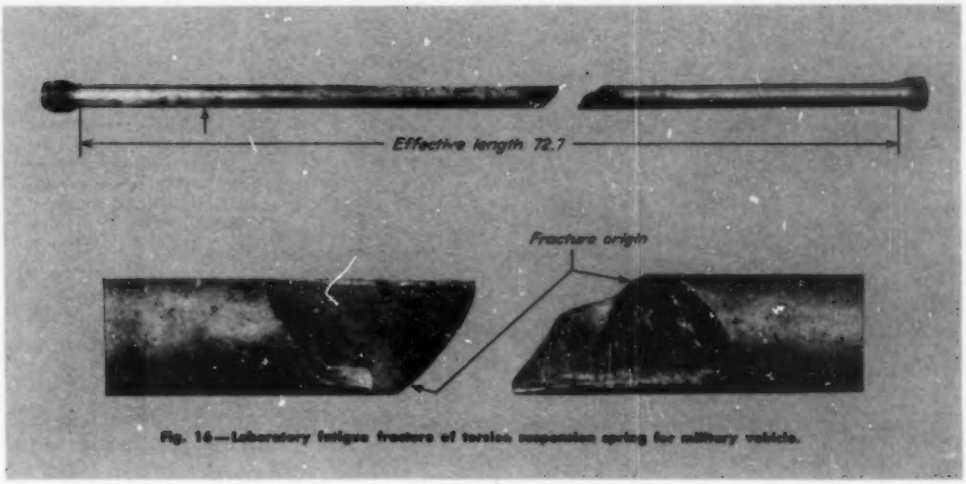


Fig. 16—Laboratory fatigue fracture of torsion suspension spring for military vehicle.

Because shot peening induced biaxial compressive stress in the affected layer, the compressive strain in the direction of the compressive component of the pre-setting load was increased. Plastic yielding in this direction was, therefore, more than doubled by the peening. But, as is shown in Fig. 17, if any damage resulted, it was less than the damage from the tensile plastic yielding in the unpeened bars.

Shot peening applied only after pre-setting was not effective because the damage from tensile plastic yielding had already occurred.

The measurement of effective residual stresses in torsion bars by the dissection method (Ref. 4) is discussed on the following pages. In only one were the measurements sufficiently refined to show the stress induced by shot peening and other important facts.

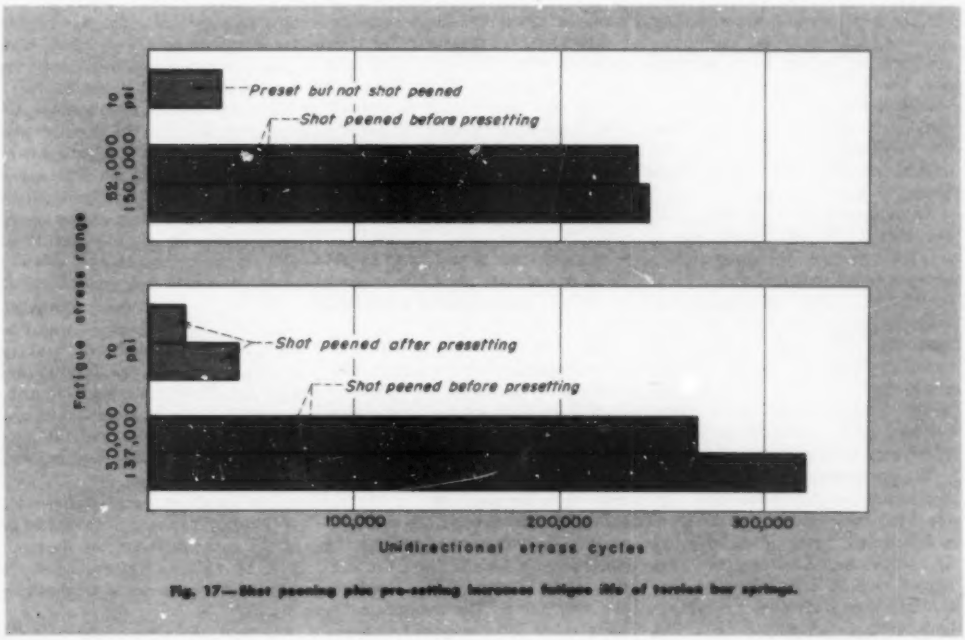


Fig. 17—Shot peening plus pre-setting increases fatigue life of torsion bar springs.

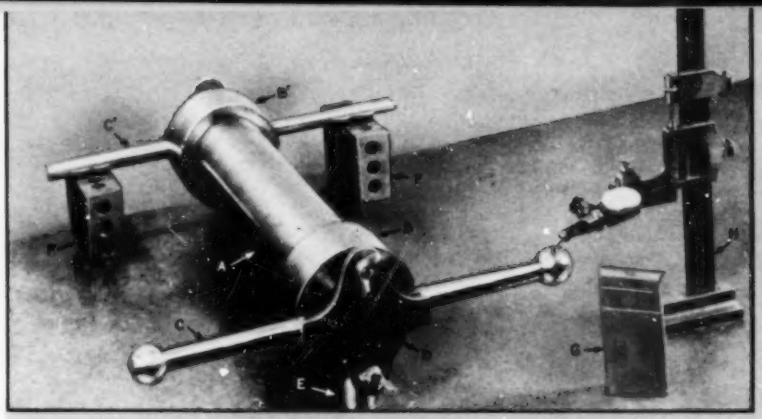


Fig. 19—Setup for measuring angular changes in section of pre-set torsion spring after removal of successive surface layers.

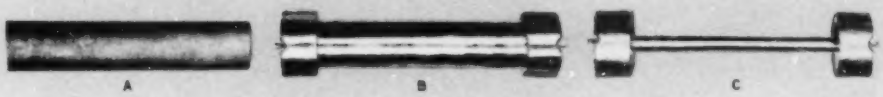


Fig. 18—Stress measurement by dissection—(A) 10 in. section cut from torsion bar.—(B) Same with V-caps after a few layers have been removed.—(C) Remainder after removal of all residually stressed metal.

Residual Stress in Bar Is Measured

To find the stress in a torsion bar measurements were made by grinding away successive layers of metal from the cylindrical surface of the bar, and measuring the resulting angle of rotation of one end of the specimen in relation to its opposite end. The magnitude of the residual torsional stress in each layer was equal to the torque necessary to hold the remainder of the bar in the angular relationship existing before the layer was removed.

As measured the specimen would not respond to the biaxial stress originally induced by shot peening, because this stress had no torsional component being compressive in both directions. The torsional overload that was applied after shot peening, however, caused unequal plastic yielding in the shot peened layer, which distorted the surface residual stress pattern so as to produce an additional torsional stress.

The specimen used for the dissection measurements is shown in Fig. 18. A ten inch section was cut from a full length torsion bar, Fig. 18 (*A*), and accurate centers were drilled in both ends. Ferrules containing V-grooves were pressed on both ends as shown at (*B*). The specimen was then ground away in 80 layers, which reduced its diameter from 2.27 to 0.662 in. as shown at (*C*). At this diameter all of the stressed metal had been removed.

The setup for measuring angular changes after the removal of each layer is shown in Fig. 19. Sine bars *C* and rest bar *C'* were clamped in the V-grooves of their respective ferrules. The rest bar *C'* and its end of the specimen were supported on the blocks *F-F'*, which were always located on marked areas on a surface plate. The near end of the specimen was supported at an equal height from the surface plate by the block *E*, which also occupied a marked spot on the surface plate.

The sine bar *C* was provided with spherical ends each spaced five inches from the center of the specimen. Both bars were located in their respective V-grooves by off center dowels to prevent any possibility of altering the location of either bar relative to the specimen.

Angular changes in the specimen were measured by determining the difference in height from the surface plate of the spherical ends of the sine bar *C*. The measurements were made by stacking Johansson gage blocks, shown at *G*, to the same height as the sphere being measured. The height of the gage blocks and the sphere were compared with a dial indicator attached to a surface gage.

To provide direct readings, the sine bar spheres were spaced ten inches apart so the differences in their heights were ten times the sine of the angle of rotation.

The surface of the torsion bar specimen between the ferrules was ground away in successive layers at a slow rate to avoid development of large magnitude residual tensile stresses. This precaution was observed although it was realized that uniform biaxial residual stresses of one sign would not contribute directly to the unwinding characteristics of the specimen. It was possible, however, that the heat of grinding would slightly alter the residual stress induced during processing in the remainder of the specimen after a layer had been removed and thus affect the residual stress measurements.

The length of the ground portion of the specimen ranged from 8.95 in. at the outer diameter, as shown in Fig. 18 (*B*), to 8.89 in. when the last layer was removed as shown in Fig. 18 (*C*).

Dimensional data relating to the

dissection processes are given in Table I. These data are given in considerable detail to indicate the painstaking accuracy that is considered essential in such studies.

It is seen that the thickness of the layers removed between measurements varies from approximately 0.001 in. near the original surface to 0.015 in. at greater depths. Special attention to the residual stress near the surface is necessary because of the greater vulnerability to fatigue and brittle failure of this portion of the specimen. Also, more frequent readings are required in regions in which rapid changes in residual stress are anticipated. When residual stress changes are small or of uniform magnitude the thickness of the layers may be increased. Unless the residual stress pattern is known with reasonable accuracy, however, important data may be lost by proceeding too rapidly.

The last column of Table I shows the angle of twist in seconds of arc for each layer of metal that was removed. This column is presented to demonstrate that in spite of the precautions taken in grinding and in measuring, the resulting angles of twist vary erratically. To overcome such variations, practice at the Research Laboraties Division of the General Motors Corporation is to make large scale plots of thickness of metal layer removed versus total deformation. A faired curve is then drawn to approximate the average of the test points, and corrected values of deformation for each layer are then taken from the faired curve.

The angle of twist in the remaining cylinder of the specimen is a measure of the mean stress in each layer removed because, prior to removal, each layer forcibly restrained the underlying cylinder from rotation through that angle. The mean stress in each layer removed is therefore that which would result from applying to the layer the torque necessary to twist the remaining cylinder through the measured angle. After the 81st layer was removed, the remaining metal was free of macro residual stress, as is indicated by the decreasing sine bar readings. The faired curve, referred to in the preceding paragaph, indicates that the diameter of zero residual stress was 0.630 in. and not 0.662 in. as is shown in Table I, first column.

Torsional residual stresses from the surface to the center of the specimen, calculated from the data in Table I, are shown by the curve $G'FO''$ in Fig. 20, which is a conventional torsional stress diagram in which no distinction is made between tensile and compressive stresses.

The curve $G'FO''$ is seen to cross the zero stress line $O'O''$ at C, thus establishing the area $CFO''C$ representing a clockwise torsional moment and the area $CG'O'C$ representing a counterclockwise torsional moment. Since to satisfy equilibrium conditions, it is necessary that the sum of these torsional moments equal zero, the accuracy of the dissection measurements may readily be tested from known stresses and the radii at which they occur. It was found that

$$\frac{\text{Clockwise moment}}{\text{Counterclockwise moment}} = \frac{-SR^2\triangle R}{SR^2\triangle R} = 0.991$$

indicating an overall error of less than one percent. This statement does not mean that the errors in residual stress magnitude are less than one percent. It is extremely

Table I — Dissection Process Dimensional Data

Layer No.	Bar Dia, in.	Layer Thickness Removed, in.	Angle of Twist Per Layer, Seconds	Total Sine Bar Reading, in.	Layer No.	Bar Dia, in.	Layer Thickness Removed, in.	Angle of Twist Per Layer, Seconds	Total Sine Bar Reading, in.
0	2.270	0	0	0	41	1.8630	0.01525	176	0.111
1	2.267	0.0015	21	0.001	42	1.8340	0.0145	196	0.1105
2	2.2648	0.0011	0	0.001	43	1.8035	0.01525	185	0.1295
3	2.2626	0.0011	20	0.002	44	1.7735	0.015	186	0.1385
4	2.2600	0.0013	21	0.003	45	1.7430	0.01525	216	0.149
5	2.2575	0.00125	10	0.0035	46	1.7135	0.01475	165	0.157
6	2.2550	0.00125	31	0.005	47	1.6830	0.01525	227	0.168
7	2.2525	0.00125	10	0.0055	48	1.6535	0.01475	196	0.1775
8	2.2500	0.00125	11	0.006	49	1.6235	0.015	227	0.1885
9	2.2475	0.00125	10	0.065	50	1.5925	0.0155	217	0.199
10	2.2450	0.00125	31	0.008	51	1.5635	0.0145	217	0.2095
11	2.2425	0.00125	10	0.0085	52	1.5335	0.015	227	0.2205
12	2.2395	0.0015	11	0.009	53	1.5035	0.015	237	0.232
13	2.2370	0.00125	31	0.0105	54	1.4735	0.015	237	0.245
14	2.2350	0.001	10	0.011	55	1.4430	0.01525	279	0.257
15	2.2320	0.0015	10	0.0115	56	1.4120	0.0155	247	0.269
16	2.2285	0.00175	21	0.0125	57	1.3820	0.015	237	0.2805
17	2.2235	0.0025	31	0.014	58	1.3520	0.015	248	0.2925
18	2.2184	0.00255	10	0.0145	59	1.3220	0.015	167	0.306
19	2.2135	0.00245	31	0.016	60	1.2920	0.015	370	0.3185
20	2.2085	0.0025	31	0.017	61	1.2620	0.015	247	0.3305
21	2.2035	0.0025	21	0.0185	62	1.2320	0.015	248	0.3425
22	2.1937	0.0049	61	0.0215	63	1.2015	0.01525	299	0.357
23	2.1835	0.0051	62	0.0245	64	1.1720	0.01475	279	0.3705
24	2.1737	0.0049	31	0.026	65	1.1415	0.01525	268	0.3835
25	2.1633	0.0052	52	0.0285	66	1.1120	0.01475	248	0.3955
26	2.1534	0.00495	62	0.0315	67	1.0820	0.015	111	0.409
27	2.1385	0.00745	62	0.0345	68	1.0520	0.015	416	0.421
28	2.1235	0.0075	82	0.0385	69	1.0220	0.015	257	0.4335
29	2.0185	0.0075	62	0.0415	70	0.992	0.015	227	0.4445
30	2.0933	0.0076	93	0.046	71	0.961	0.0155	197	0.454
31	2.0786	0.00735	82	0.05	72	0.932	0.0145	196	0.4635
32	2.0635	0.00755	73	0.0535	73	0.902	0.015	144	0.4705
33	2.0435	0.0100	103	0.0585	74	0.8715	0.01525	166	0.4785
34	2.0235	0.0100	123	0.0645	75	0.842	0.01475	82	0.4825
35	2.0035	0.0100	114	0.070	76	0.812	0.015	83	0.4865
36	1.9833	0.0101	113	0.0755	77	0.782	0.015	62	0.4895
37	1.963	0.01025	124	0.0815	78	0.752	0.015	41	0.4915
38	1.9435	0.00975	114	0.087	79	0.722	0.015	41	0.4935
39	1.9235	0.0100	123	0.093	80	0.692	0.015	11	0.494
40	1.8935	0.015	196	0.1025	81	0.662	0.015	20	0.495

difficult to measure stress near the surface of a specimen and the stress magnitude in this region is subject to relatively large errors. Also, the dissection method can, at best, measure only macro stresses giving no indication of the sign or the magnitude of micro stresses that may be present.

Residual Stress from Plastic Yielding

Torsional residual stresses, represented by the line FG, were developed during processing as a result of plastic yielding when the torsion bar was subjected to the presetting overload. At the surface this stress $O'G$ is compressive and equal to 18,000 psi. The residual stresses represented by the line $O''F$ occurred in metal that had experienced no plastic deformation but was elastically stressed by the permanent set of the spring. The portion GG' of the residual stress equal to 14,000 psi is a remnant of the compressive stress induced during the shot peening operation, which was applied prior to pre-setting.

The point F on the residual stress line $O''G'$, Fig. 20, lies at a radius of 0.315 in., which as was shown by the faired curve is the limit of plastic yielding. This point marks the limit of elastic behavior of the torsion bar steel when the five presetting overloads, having maximum nominal surface stress values of 255,000 psi, were applied. The indicated yield stress

$$S_y = \frac{R \text{ max}}{R \text{ min}} \times S \text{ max} = \frac{0.315}{1.135} \times 255{,}000 = 71{,}000 \text{ psi}$$

is a very low value for this steel, which had a hardness of Rockwell C 49. The question arises whether the initial torsional yield strength at this depth may not have been depressed through the action of radial and tangential compressive stresses.

Permanent Set Measurements

The angle of permanent set can be found from Fig. 20 by extending the line $O''F$ to intersect the surface of the specimen at F'. The stress scale shows this intersection to occur at 73,000 psi. The nominal angle of twist during pre-setting was given as 90 deg. (Ref. 4), but this value was arbitrarily reduced to 86 deg. by the author, equal to 255,000 psi nominal stress to allow for elastic and plastic losses in the splines and loading gear during overloading.

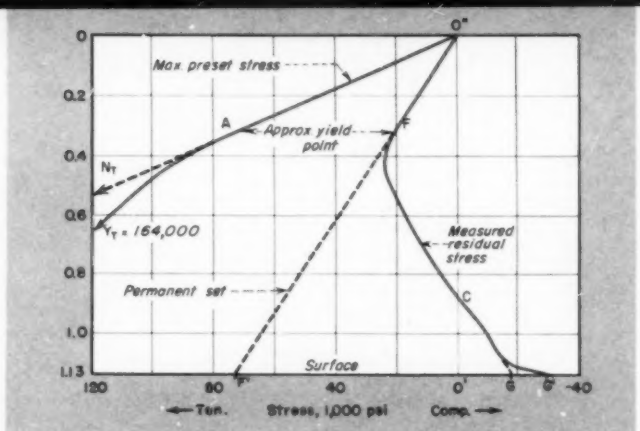


Fig. 20—Residual stress in a tank torsion bar spring. Reconstructed from dissection measurements showing reduced surface tensile stress, magnitude of permanent set, and yield stress of surface and sub-surface metal.

From these values the indicated permanent set angle is

$$\theta = \frac{73{,}000}{255{,}000} \times 86 = 24.5 \text{ deg}$$

The angle of permanent set may also be calculated from the final sine bar reading in column four of Table I and the ratio of effective length of the torsion bar to the length of the ground dissection specimen, Fig. 18 (C)

$$\sin \theta = \frac{72.7}{8.89} \times \frac{0.495}{10} = 0.4$$

$\theta = 23.5$ deg

This value is presumably more accurate than the preceding because it is obtained from the original test data.

Neither of these angular values agrees with the nominal permanent set angle of approximately 32 deg measured during processing (Ref. 4). There are reasons to suspect errors in the latter measurement but the angular magnitude of these probable errors cannot be accurately estimated.

It is also possible that changes occurred in the magnitude of the residual stresses during fatigue testing of the torsion bar spring prior to the dissection stress analysis. The bar from which the dissection specimen was taken was subjected to 70,000 stress cycles of unidirectional torsional loads at nominal stresses ranging from 20,000 to 145,000 psi. Although the torsion bar spring was not broken, a portion of the test fixture failed during the test. It is possible that a large negative torsional load was applied by the inertia of the bar and the attached splined loading members upon sudden release of the load.

Errors in permanent set angles, whatever their sources, would not alter the indicated initial yield strength of 71,000 psi but could have altered the magnitude of the surface yield stress obtained from the dissection stress data.

References

1. A. M. Wahl—"Mechanical Springs", Penton Publishing Company
2. J. O. Almen—"Fatigue Weakness of Surfaces", PRODUCT ENGINEERING, November 1950, p. 117.
3. J. O. Almen—"Fatigue Failures are Tensile Failures", PRODUCT ENGINEERING 1951, p. 101.
4. H. O. Fuchs and R. L. Mattson—"Measurement of Residual Stresses in Torsion Bar Springs", Society for Experimental Stress Analysis *Proceedings;* Vol. 4, No. 1; 1946; p. 64.
5. R. K. Mattson and J. O. Almen—"Effect of Shot Blasting on Physical Properties of Steel," Final Report, Part II, O. S. R. D., No. 4825. Published by National Defense Committee of the Office of Scientific Research and Development, War Metallurgy Division, 1945, p. 23.

Practical Considerations In Instrument Gear Design

Reasons why undercut pinions should be avoided. Comparison of the economical and practical aspects of the 14½ degree pressure angle system and the 20 degree involute Fine Pitch system when applied to instrument gearing. Undercut as affected by worn generating tools. Interference that may result from shaving or grinding. Influence of pressure angle on tooth strength, wear and accuracy.

L. M. DAVISON

INSTRUMENT GEARING that generally falls in the class of Fine Pitch Gearing is full of myths and fancies. A survey of many instruments employing precision fine pitch gears discloses an appalling lack of knowledge of good instrument gear design practices.

A disregard is apparent for newly developed standards, especially created to meet the requirements of this highly specialized field. Also evident in many instrument gear designs, is the utter lack of appreciation of practical considerations. Economic values are often lost sight of, purely because the types of instruments using this gearing are not on the same level cost-wise, nor are they subjected to the same market research as are consumer goods.

Safety factors, which in comparable devices manufactured for public consumption might be quite adequate, are multiplied ten-fold. A great deal of second guessing is in evidence in many instrument gear designs. The desire to hang on tenaciously to archaic systems of tooth design seems generally to permeate this field. The more important practical considerations are subordinated to purely academic ones, consequently the forest is often lost for the trees.

Many designers of instrument gearing insist on using the 14½ deg pressure angle tooth form system. Their reasoning is based on the fact that backlash between engaging gear teeth is related to changes in center distance. Since lost motion resulting from backlash must be kept to a minimum in many instruments, it is supposed that low pressure angles are to be preferred to high ones.

It is also argued that the operating temperature range, usually 135 to 160 F, causes changes in backlash if the gears are made of a material that has a different coefficient of linear expansion than that of the supporting frame casting. Consequently, gears of low pressure angles, in which the ratio of tooth-thickness to center-distance is less than in those of high pressure angle, are preferred.

Such reasoning is purely academic because it ignores important practical considerations.

Gears are used to transmit power and motion. In most instrument gears, power requirements are low. Beam strength, therefore, excepting where shock loads are present, is a minor consideration. The chief function of gears in a sighting instrument, for example, is to transmit motion to optical elements. In such gearing, uniform angular motion and maintenance thereof, through surface durability of gear teeth, is the main objective.

The weak link in the chain of a gear tooth system is a pinion with a small number of teeth. Unfortunately to avoid multiple reductions in many instrument gear trains, such pinions must be used; and if they are to be efficient and economical, careful consideration must be given to their design and manufacture. If gear trains could be designed to have large numbers of teeth in all the gears and pinions, considerations as to the effect of pressure angle on tooth form would be unimportant. Obviously, many such gear trains would not be practical nor economical.

In generating pinions of involute form having a small number of teeth, the tooth profiles are undercut. As shown in Fig. 1, undercut is the condition where any part of the fillet curve

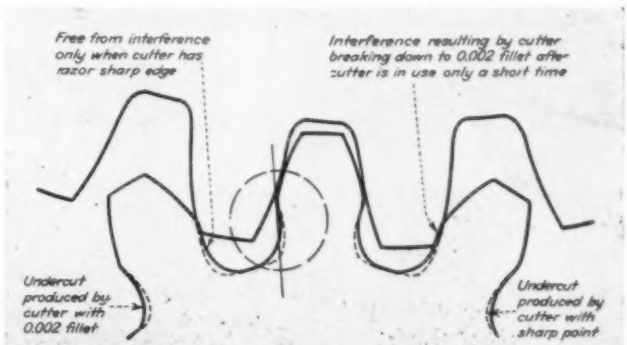

Free from interference only when cutter has razor sharp edge
Interference resulting by cutter breaking down to 0.002 fillet after cutter is in use only a short time
Undercut produced by cutter with 0.002 fillet
Undercut produced by cutter with sharp point

Fig. 1 — Interference developed by edge breakdown of generating cutter that causes engaging gear to "hook in" and roll rough.

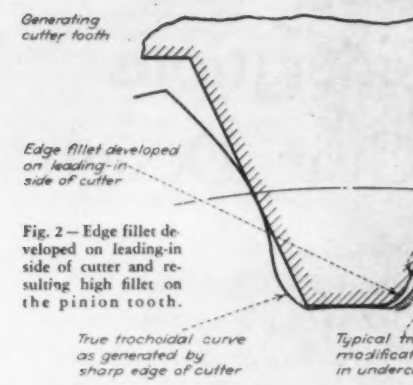

Generating cutter tooth
Edge fillet developed on leading-in side of cutter
True trochoidal curve as generated by sharp edge of cutter
Typical trochoid modification in undercut gears

Fig. 2 — Edge fillet developed on leading-in side of cutter and resulting high fillet on the pinion tooth.

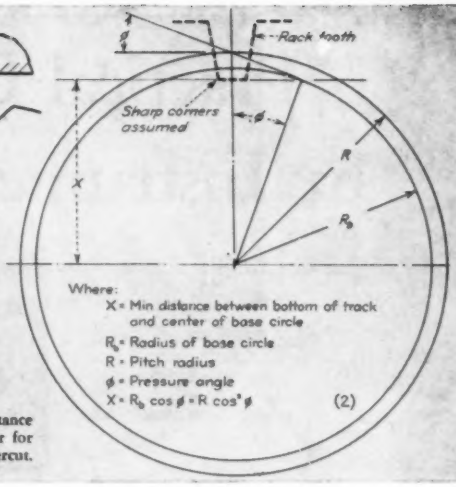

Rack tooth
Sharp corners assumed
X
R
R_b
Where:
X = Min distance between bottom of track and center of base circle
R_b = Radius of base circle
R = Pitch radius
ϕ = Pressure angle
$X = R_b \cos \phi = R \cos^2 \phi$ (2)

Fig. 3 — Layout for determining minimum distance between sharp rack cutter and base circle center for generating involute gear teeth without undercut.

lies inside a line drawn tangent to the lowest point of the working profile (See A.G.M.A. Standard Gear Nomenclature No. 112.02). The undercut is produced by the edge of the generating tool as the tool sweeps out the tooth profile.

When the edge of the generating tool is sharp, it sweeps out the sufficient and necessary clearance for the tip of the teeth of the mating gear as shown by the dash lines of Fig. 1. This condition is seldom achieved because soon after the tool is put in use its razor edge breaks down.

This breakdown of the tool edge results in a high fillet on the pinion teeth as shown by the full lines of Fig. 1. The high fillet interferes with the tips of the teeth of the mating gear. Since most of the metal is removed by the "leading in" side of the generating tool, a larger edge fillet is developed on that side. Consequently, it is common to find in undercut pinions a higher trochoid curve on one side of the tooth than on the other.

If gears are generated with a sharp rack-shaped tool that extends too far below the base circle, undercut will be developed as shown by the dash line of Fig. 2. This undercut can be considered to be the removal of interference by the generating tool. To avoid this interference, the cutter can extend only a limited distance below the base circle.

In Fig. 3 the dimension X is the limiting minimum distance between rack cutter with sharp corners and center of base circle to generate an involute gear tooth without undercut. Where

R_b = radius of base circle
R = pitch radius
ϕ = pressure angle of rack tooth

the distance X can be expressed as

$$X = R_b \cos \phi = R \cos^2 \phi$$

For example, to avoid undercut (up to the working depth) of a 12 tooth pinion of 48 diametral pitch and 14½ deg pressure angle, the outside diameter of a standard pinion would have to be enlarged 0.026 inches.

Undercut pinions, particularly in instrument applications that operate

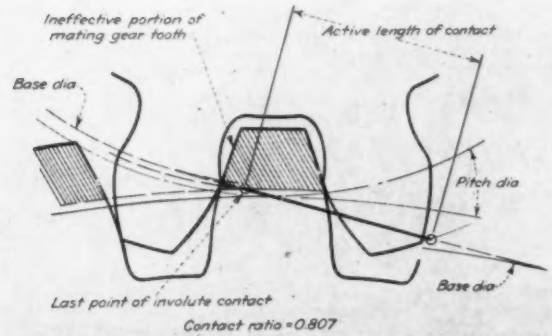


Fig. 6 — Contact loss resulting from undercut in a 14½ deg pressure angle 12 tooth pinion meshing with a 30 tooth gear.

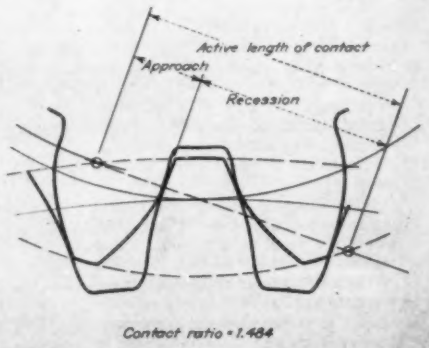


Fig. 7 — Active length of contact of 12 tooth pinion, made in accordance with ASA B6.7-1950, meshing with a 36 tooth gear.

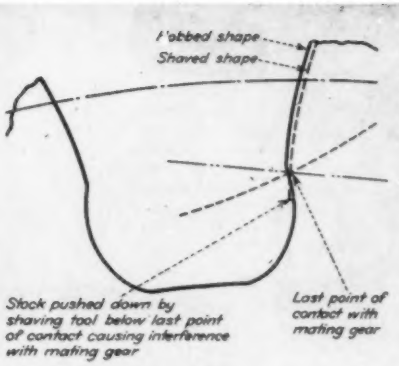

Hobbed shape
Shaved shape
Stock pushed down by shaving tool below last point of contact causing interference with mating gear
Last point of contact with mating gear

Fig. 4 — Interference caused by stock that has been pushed into undercut by shaving tool.

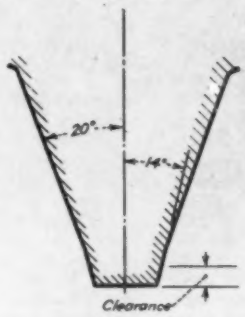


Fig. 5 — Profile of protuberance hob used to produce an undercut to provide clearance for shaving tools.

metal to metal, generally have involute interference left by the generating tool.

Another type of interference is that which occurs in undercut pinions that have been shaved, Fig. 4. This interference results from the tendency of the shaving tool to push stock into the undercut beyond the last point of engagement. This excess stock in the fillet causes the mating gear teeth to "hook in" when operating metal to metal, and results in jumpy action.

To provide clearance for shaving tools or grinding wheels, sometimes gears (not pinions) are deliberately undercut below the last point of contact in the clearance zone. To obtain such clearance, special hobs known as protuberance hobs, Fig. 5, are used.

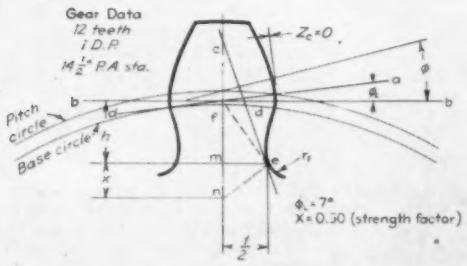
Undercut pinions lack continuous action. A good gear engineering job is based on a thorough knowledge of tooth action and its practical application. A graphical portrayal of tooth action drawn to an enlarged scale is essential to the analysis. Such an analysis will disclose that undercut pinions lack continuous action. Fig. 6 shows a 12 tooth pinion of 14½ deg pressure angle engaging a 30 tooth gear. It will be noted that: (a) The contact ratio is less than unity—being 0.807 of a base pitch increment (See "Spur Gears", 1928, Chap. IV, Buckingham); and (b) An appreciable amount of the addendum of the 30 tooth gear, shown by the shaded area, could be removed, since this portion of each tooth serves no useful purpose.

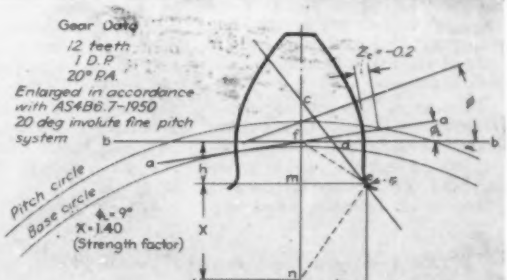
It is of interest to note that the contact ratio between such a 12-tooth pinion and a rack does not increase at all. Actually, the contact ratio of 0.80 is the same for a 12 tooth pinion of 14½ deg pressure angle, whether it engages a 24 tooth pinion or a rack. In the 14½ deg generated tooth form system, all pinions with fewer than 32 teeth are undercut.

Contrast this condition with pinions made in accordance with the 20 deg Involute Fine Pitch System, A.S.A.B-6.7-1950. In this system, all pinions with fewer than 17 teeth are enlarged to avoid undercut up to the working depth. Two 12 tooth pinions meshing together have a contact ratio of 1.135 base pitch increment against 0.034 for two similar pinions of 14½ deg pressure angle made to standard proportions. Fig. 7 shows a 12 tooth pinion, made in accordance with the A.S.A. system meshing with a 36 tooth gear. The contact ratio in this combination is 1.484 or 84 percent greater than with a 14½ deg standard pinion.

Undercut pinions are considerably weaker than those without undercut. For the purpose of comparison, two 12 tooth pinions are shown in Figs. 8 and 9. The static strength factor for each has been derived from A.G.M.A. Standard, No. 220.01, Strength of Spur Gears. This standard requires a graphical analysis. For the sake of completeness, all of the graphical elements described in this standard are shown in Figs. 6 and 7, although in instrument gearing, the ones of interest are those elements having to do with static loading.

It will be seen from Figs. 8 and 9, that the strength factor of the pinion





NOMENCLATURE

ϕ_1 = Load pressure angle
X = Strength factor
t = Tooth thickness at section of max stress
r_f = Fillet radius
h = Load height
Z_c = Load distance

Fig. 8 — Strength and tooth form factors derived from AGMA Standard 220.01 for 1 DP, 14½ deg pressure angle, 12 tooth standard pinion.

Fig. 9 — Strength and tooth form factors derived from AGMA Standard 220.01 for 1 DP, 20 deg pressure angle, 12 tooth pinion enlarged in accordance with ASA B6.7-1950 involute Fine-Pitch System.

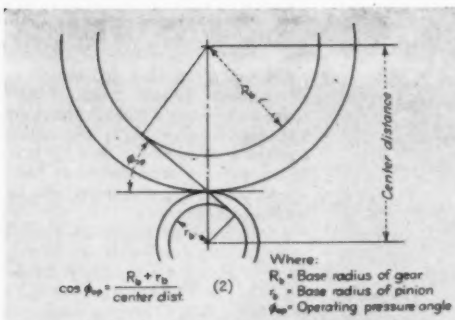

Center distance
$\cos \phi_{op} = \frac{R_b + r_b}{\text{center dist.}}$ (2)
Where:
R_b = Base radius of gear
r_b = Base radius of pinion
ϕ_{op} = Operating pressure angle

Fig. 10 — Layout showing the relationship of operating pressure angle to center distance.

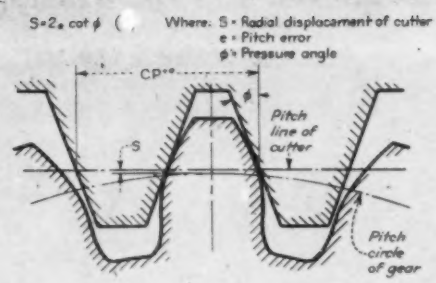

$S = 2e \cot \phi$
Where: S = Radial displacement of cutter
e = Pitch error
ϕ = Pressure angle
CP
Pitch line of cutter
Pitch circle of gear

Fig. 11 — Effect of cutter pitch error on radial displacement of cutter.

made in accordance with A.S.A. B6.7-1950 is 1.40, while that of the 14½ deg pressure angle is 0.50. The A.S.A. pinion therefore, is 180 percent stronger than the 14½ deg undercut pinion. Design conditions, therefore, could be satisfied with materials having a correspondingly lower tensile strength, provided the proper choice of tooth shape is made.

A comparison of three typical gear materials used in instrument gearing is given in Table I. In each case, averages of tensile strength and yield strengths are given for direct comparison. Most steel gears used in instruments are unhardened. Improved physical properties can be obtained by heat-treatment but surface durability, while highly desirable, cannot be traded for loss in accuracy caused by hardening distortion. To remove distortions, hardened gears would require grinding. While many fine pitch gears are ground, the vast majority are cut and subsequently shaved.

The surface durability of aluminum alloys can be increased by anodizing, and by the hard coating methods recently developed, without introducing tooth distortions.

The point is: Why use materials that are difficult to machine, have a greater differential of thermal expansion than that of the castings, which present backlash problems, when functional requirements can be met by proper engineered tooth design? A good gear engineering job requires that not more than a reasonable factor of safety be used, because it is just as bad to over design as to under design.

To summarize: Undercut pinions should be avoided because (a) they have interference and cause erratic tooth action; (b) they lack continuous tooth action; and (c) they are considerably weaker than those without undercut.

Influence of Pressure Angle on Gear Tooth Accuracy

The exponents of 14½ deg pressure angle hold that to control backlash in assembly, low pressure angles must be used. It is contended, that since changes in center distance and radial displaceent caused by composite tooth errors are related to the tangent of the pressure angle, low pressure angles are preferred.

It has been shown in the previous discussion, however, that the change in center distance that results from differential thermal expansion can be overcome by correct tooth design. It has also been shown that undercut pinions should not be used. To avoid undercut, pinions should be enlarged. When pinions are enlarged without a corresponding reduction in the mating gear, their operating pressure angle is increased.

Involute gears have no pressure angle until meshed with other gears on their operating centers. There are several concepts of pressure angle; standard pressure angle, generating pressure angle, and operating pressure angle. A complete definition of pressure angle can be found in A.G.M.A. Standard Gear Nomenclature No. 112.02. Fig. 10 shows the relationship of operating pressure angle to center distance.

Consider two 12 by 36 tooth combinations of 1 DP, in which the 12-tooth pinion is enlarged to avoid undercut, but the gear is cut to standard dimension. Let one of these combinations be generated with a 14½ deg cutter, and the other be generated with a 20 deg cutter.

The 14½ deg combination will operate at a pressure angle 33 percent greater than standard, and at an increased center distance of 0.6239 in., while the 20 deg combination will operate at an operating pressure angle only 9 percent greater than standard, and at an increased center distance of 0.2982 in. Note, however, that the 20 deg combination could be made to operate at a standard center distance and standard pressure angle by reducing the 36 tooth gear an amount equal to the pinion enlargement. To do the same thing with the 14½ deg combination, the gear mating the 12 tooth pinion would be required to have 52 teeth.

In Table II values are given for the minimum number of teeth in gears mating with enlarged pinions for operation at standard center distance and standard 14½ deg and 20 deg pressure angles. The contact ratio between two equal pinions is also given.

The point that is all too often overlooked in the argument of 14½ deg versus 20 deg pressure angle is this: The very thing that reacts more favorably to backlash (more radial displacement for a given change in tooth

Table I—Comparison of Materials Used in Instrument Gearing

Material	Condition	Tensile Strength, psi	Yield Strength, psi	Coefficient of Thermal Expansion, F	Expansion Factor
Steel A151 1040	190 Bhn	100,000	70,000	0.0000066	1.00
Bronze ASTM B 138-49	200 Bhn	115,000	68,000	0.0000160	1.50
Aluminum 75S-T6	Hard rolled	77,000	66,000	0.0000123	1.86

thickness) in the 14½ deg system, causes correspondingly greater trouble in maintaining total composite error. This is like robbing Peter to pay Paul. It invariably happens, that uniform angular motion, and the factors that make its obtainment difficult, far outweigh backlash considerations. Backlash can be eliminated if need be, in several ways such as spring loading, but spacing accuracy must be built into equipment and tooling.

The effect of cutter pitch error on radial displacement is shown in Fig. 11. The cutter manufacturer must have a working tolerance, whether he makes hobs, gear shaper cutters, shaving tools or index plates for grinding equipment. He sets limits on spacing that he can consistently guarantee. No cutter or hob is perfect.

Spacing errors in cutters shown in Fig. 11 as *e* cause changes in radial displacements, which are related to the tangent of the cutter pressure angle. The lower the pressure angle the greater, percentagewise, is the total composite error produced in the work. That is the reason why cutter and master gear manufacturers require, generally, greater tolerance (or more money for similar accuracy) for tooling of low pressure angle than high pressure angle. Thus another myth is exploded.

All this business about greater profile sensitivity in high pressure angle pinions, and the difficulty to maintain profile accuracy are fancies and inventions designed to plague the poor gear engineer. It is admitted that involute gear teeth slide over each other.

There is no such thing as rolling contact in involute gears, except at an instantaneous point at the pitch line. In Fig. 12 is shown the relative sliding between two involutes.

In Fig 12 all the base circles are marked off in a number of equal spaces, and tangent lines are drawn from the division points on the base circles to the involute profiles. Note that the divisions of the base circles are equal and the corresponding arcs on the involute profiles are unequal, increasing in length as they depart from the base circles. Corresponding divisions on the base circles and involute profiles are numbered for comparison, and indicate those segments of the profiles that contact each other during equal angular increments of rotation of base circles.

The difference between the relative lengths of the mating arcs on the profiles is the slippage between the profiles. The greatest rate of slippage takes place when the outside end of one profile is in contact with its mating profile in the vicinity of the base circle.

When the center distance is increased as shown in Fig. 12(B), causing an increased operating pressure angle, the sliding is less. The reason for this reduced sliding is that the contact between the involute profiles takes place farther away from the base circles; a good argument for using enlarged pinions.

There is a preponderance of evidence, both academic and empirical, in favor of the 20 deg involute system and the obsolescence of the 14½ deg system. One needs only to note the trend in gearing standards both in this country and abroad; American standards for 20 deg Involute Fine Pitch Gears as an example, covering all types of gears. British and European standards employ 20 deg pressure angle. Relatively speaking, until recently, there were several systems of bevel gears, each employing a different pressure angle. Today, the largest manufacturer of bevel gear equipment strongly recommends the 20 deg system.

Back in an era when industry was emerging from cast to cut gears, there might have been justification for using 14½ deg. It was chosen at that time, because the sine of 14½ deg is closely equal to ¼, which is easy for the millwright or pattern maker to lay out.

When all the evidence is carefully weighed and sifted, both on the practical and academic side, and when fancy is replaced with fact, engineers will cease to use a system that has outlived its usefulness.

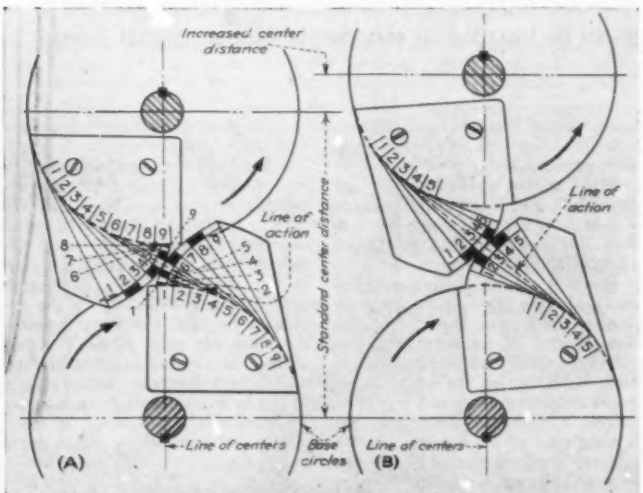


Fig. 12 — Involute arc segments attached to base circles to demonstrate the increase in operating pressure angle and reduction in sliding obtained by increasing the center distance.

Table II—Minimum Teeth in Gear Meshing With Enlarged Pinion For Operation at Standard Center Distance

n, Number of Teeth in Pinion	*N*, Recommended Min. No. of Teeth in Gear	Contact Ratio Two Equal Pinions
For 20 deg Pressure Angle		
7	42	0.826
8	39	0.929
9	36	1.032
10	33	1.135
11	30	1.186
12	27	1.238
13	25	1.290
14	23	1.344
15	21	1.398
16	19	1.436
17	18	1.511
(Over 17 teeth no enlargement is required)		
For 14½ deg Pressure Angle		
12	52	0.034
13	51	0.100
14	50	0.166
15	49	0.231
16	48	0.297
17	47	0.362
18	46	0.427
19	45	0.492
20	44	0.557
21	43	0.622
22	42	0.687
23	41	0.752
24	40	0.807
25	39	0.807
26	38	0.807
27	37	0.807
28	36	0.807
29	35	0.807
30	34	0.807
31	33	0.807
(Over 31 teeth no enlargement is required)		

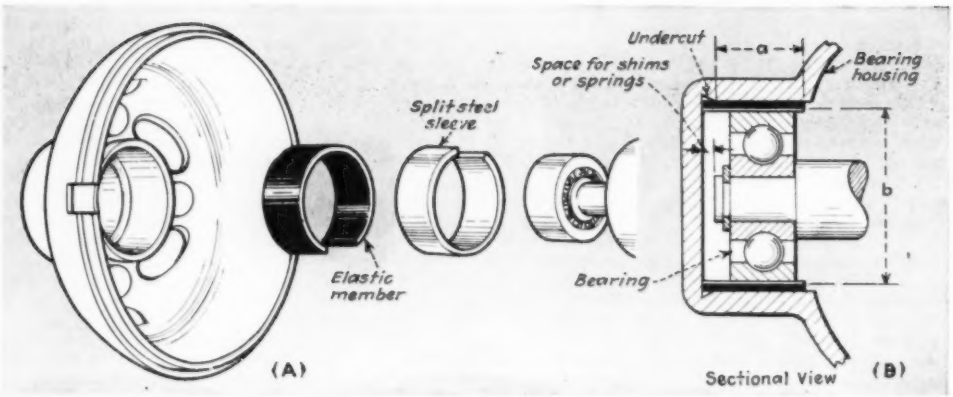


Fig. 1—Resilient mounting requires two additional elements: a strip of rubber or neoprene and a piece of thin steel. (A) With the selection of a proper interference fit, the assembly can be made quite easily. (B) Although the elastic member exerts pressure on outer race of the bearing, it is sufficiently low so as not to interfere with the close internal clearances of the bearing.

Elastic Girdles For Ball Bearings

Elastic mountings for ball bearings have proven practical and economical for applications on electric motors, dynamotors, and many other types of industrial equipment. Neither line boring of assembled housings nor close tolerances on bearing bore dimensions are necessary. Bearings can be installed in soft metals without special inserts.

J. H. STARK

Fractional-Horsepower Motors Div.
General Electric Co.

METHODS OF MOUNTING BALL BEARINGS vary widely with the type of application. In the simplest and most widely used method, the bearing is pressed on the shaft and the outer race floats with a slip fit in the housing. In designs having appreciable thermal differential expansion, a spring is often included to pre-load one of these bearings and to take up any relative expansion.

There are many applications where this arrangement is satisfactory. However, it has definite limitations if long life is expected. Some of these are:

1. The slip fit between the bearing outer race and the housing must be carefully controlled to prevent chatter and wear of the housing. In some cases, selective bearing fits are required.

2. Vibrating and unbalanced loads increase the housing wear.

3. Aluminum, malleable iron and other soft metals generally must be provided with a steel sleeve insert to form the bearing housing; this means additional close tolerances.

However, sources (principally German) advocate this "slip fit" construction on the premise that creeping or slow rotation of the outer race presents a constantly changing bearing surface which carries the load. It requires extreme accuracy and very close control. Furthermore, the wear surface is transferred to the housing. In this country, most sources object to the wear and do not stress the creepage characteristic.

For more severe applications, a locked construction is often used, wherein both the inner and outer races are fixed to their respective members on at least one end of the shaft. The other end has a floating bearing to provide for differential thermal expansion between the shaft and the housing. The most severe service frequently requires that all races be locked. Such a construction is shown in Fig. 2 where a roller bearing is used on one end to take up the expansion by axial movement between the inner and outer races. The ball bearing at the other end takes the trust in both directions. Such methods to obtain locked bearing construction are more costly as a result of more complicated parts which require more machining.

Resilient Method of Mounting

To avoid housing wear without the expense of locked-bearing construction, many methods have been pro-

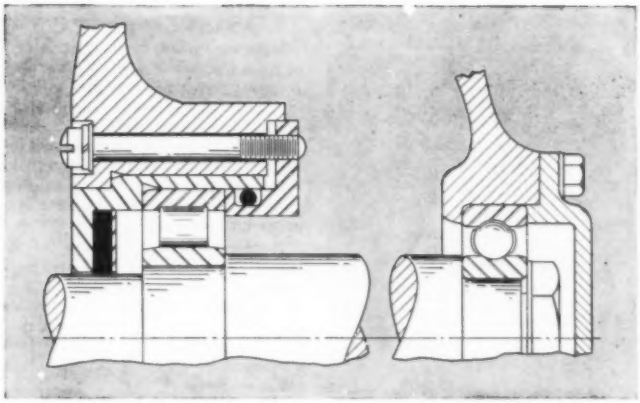


Fig. 2—Locked construction where both the inner and outer races of the ball and roller bearings are positively fixed. The roller configuration shown at the left permits longitudinal thermal displacement between the shaft and the housing.

posed to prevent rotation of the outer race. These have functioned with varying degrees of success. The design illustrated in Fig. 1 has the floating bearing characteristics and, at the same time, has reduced manufacturing costs.

In this design, the bearings are pressed onto the shaft journals in the normal way. The outer race, fits into a bearing housing which is lined with a synthetic rubber strip. This elastic strip is held in place by a split steel ring which also acts as a seat for the outer race of the bearing. The bearing is pushed into this resilient lined housing with a small interference fit. The rubber is thus put under compression, causing the split steel sleeve to grip the outer race of the bearing and thereby prevent its rotation even with vibrating or unbalanced loads. This elastic girdle also permits axial movement of the bearing in the sleeve to accommodate differential thermal expansion. Such movement is the result of deflections of elastic under shear stress.

This resilient member also permits small misalignments between the bores in the housings. Thus the bearing supports can be completely machined in one set-up. No additional machining operations are necessary to maintain the extremely close tolerances required in conventional housings. Bore dimensional tolerances are within the limits of normally used turret lathes. The elastic support means better concentricity between the bearing housing bore and the associated elements.

The elastic member is a strip of neoprene or synthetic rubber. It is purchased in sheets and ground to the required thickness on a surface grinder and then sheared to the size required. The split steel sleeve is made on a wire-bender from scroll stock.

These parts are assembled in the bearing housing as shown in Fig. 1. The tolerances of all parts are such that the proper interference fit is chosen to insure a good grip on the outer race of the bearing to prevent it from turning, and at the same time allow for the normal assembly or disassembly of the unit. In this way, selective assembly is unnecessary, and the benefits of locked bearing construction have been obtained.

Load-Deflection Characteristics

To determine the characteristics of the resilient member in the assembly, a fixture as illustrated in Fig. 3 was constructed so that bearings of various sizes could be mounted and tested. The data obtained from a typical bearing are illustrated by the curves in Fig. 4 which are from many tests using production parts over full range of fits from zero to 0.010 in. interference. With a zero interference fit between the bearing and the steel sleeve, the slope is always less than when appreci-

Fig. 3—Test fixture used to find the static spring rate curves shown in Fig. 4. Two ways to alter the spring rate are by either changing the hardness of the area of the elastic member.

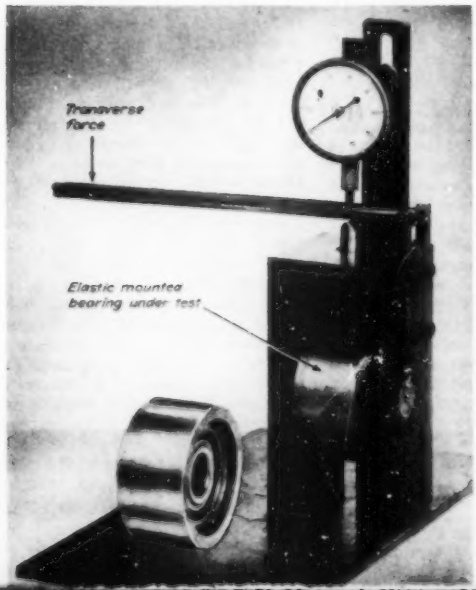
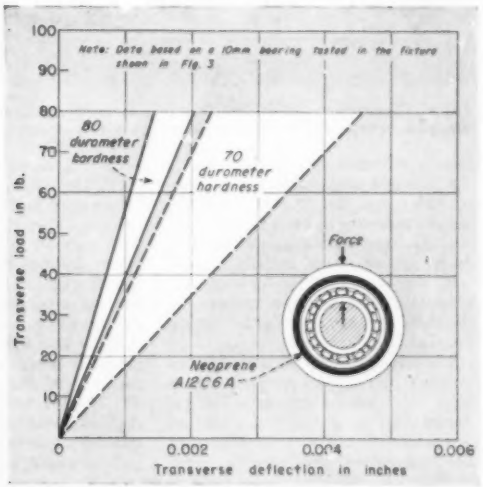


Fig. 4—Static load-deflection curves of an elastic-mounted ball bearing. Curves show the possible variation due to dimensional tolerances. Parts tested ranged from 0 to 0.010 in. interference.



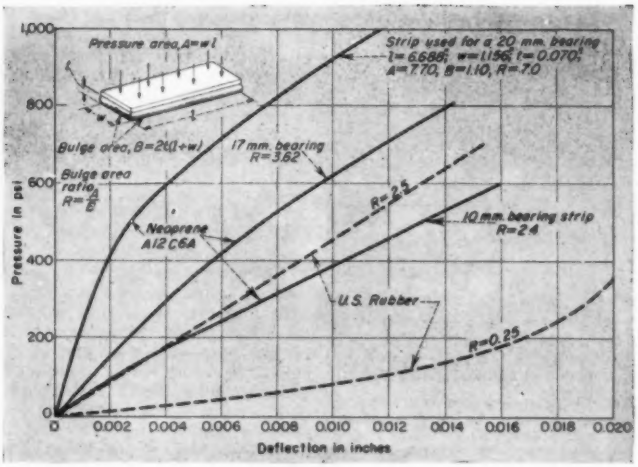


Fig. 5—The bulge area also influences the spring constant. Curves illustrate this effect on three bearings tested. For practical purposes, the nature of the material causes assemblies with bulge-area ratios greater than 2.5 to closely approach th dotted curve R = 2.5.

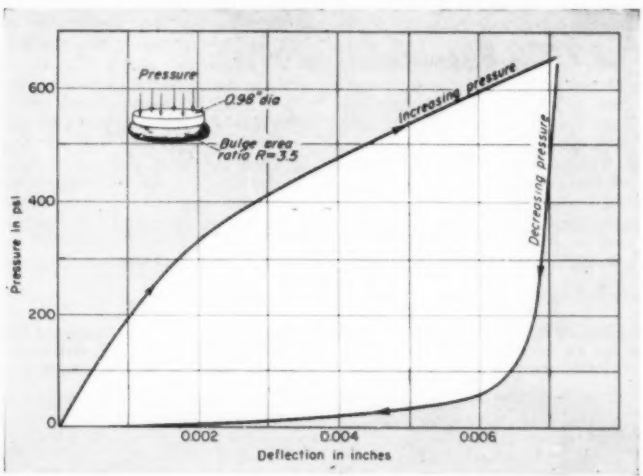


Fig. 6—Characteristics of neoprene resemble those of natural rubber. Curve indicates the high hysteresis. The recovery factor of elastic materials facilitates assembly.

able interference fit is used. This is due to slight inaccuracies in the measurements and the fit which is considered as zero or line to line is actually slightly loose to the extent that the entire surface is not initially in contact. The slope of these curves can be altered by changing the hardness of the elastic member, and also by varying the elastic contact area.

Pressure-deflection characteristics of neoprene correspond very closely to those for natural rubber. This is shown in Fig. 5 where a series of curves are plotted of a 70 durometer hardness rubber and neoprene with bulge-area ratios ranging from 7.0 to 0.25. The bulge area ratio is the ratio of pressure surface to free exposed surface. The three solid lines are from tests on neoprene strips for 10, 17 and 20 mm bearings. An interesting characteristic in these curves is that for a bulge-area ratio R of 2.5, the curve is essentially a straight line. Also, beyond the initial deflection region, all other curves appear to be parallel with the curve $R = 2.5$. In the 20 mm bearing-strip curve, the slight departure from the normal characteristics may be a result of a higher ratio of elastic width to length.

From these curves, it is apparent that increasing the bulge-area ratio will increase the initial slope of the curve. A higher durometer hardness will also increase both the initial slope and the stabilized slope of the curve. Another factor is that the shape or configuration of the pressure area influences the length of the elastic stretch or flow path from the pressure region to the bulge or emergence point.

Another interesting property of the elastic mounting is its high hysteresis. A typical curve is shown in Fig. 6. In decreasing the pressure, the deflection and pressure readings are very stable, above 100 psi. That is, with the press movement stopped, the deflection and pressure readings always correspond. However, if the press is stopped at or below 100 psi, the pressure will immediately increase 40 or 50 percent with no change in deflection.

This characteristic is emphasized because of its effect on assembly. The curves in Fig. 5 indicate that the pressure exerted on bearings, where the elastic member has a relatively high bulge-area ratio (as in larger bearings) would be quite high so that for any appreciable interference fit the force for assembly would be prohibitively large. However, the high hysteresis makes the actual pressure approach that of the straight-line curve, $R = 2.5$.

Tests on the flow of the elastic member at higher temperatures were made using a 17 mm bearing and the fixture in Fig. 3. The unit was placed in an oven at 90C, with a static load of 80 psi. After several weeks under these conditions, there was no detrimental effects. Service testing has confirmed this fact that such flow is not objectionable.

Specifications on neoprene indicate that it will take a permanent set of 30 to 50 percent. This means that if compressed 0.004 in. for the specified 168 hours at 70C, it will recover only 0.002 in. The study which was made did not investigate the temperature-time effect for permanent set. However, some strain relief does take place almost immediately on assembly and continues over the years until at some future time depending on conditions under which it is used, the strain would be largely relieved.

While the normal uses and temperatures encountered over several years have had no appreciable effect on the durometer hardness, age hardening does occur on exposed parts at higher temperatures. The rate of increase in durometer hardness is a function of temperature and time. Service experience and life tests on the elastic strip have shown no indication of age hard-

ening. Continuous temperatures over 100C would probably result in some hardening, but this would be unimportant since the grip on the bearing would not be relaxed.

Oil swell from contact with bearing greases has been no problem because of the small area exposed and the resistance of neoprene to such materials.

Restraining Force of Elastic

To determine precisely the pressures exerted on the bearing by the elastic, tests were run on many different interference fits and on three bearing sizes. The measured force required to slip or rotate the outer race relative to the steel sleeve is plotted in Fig. 7. The range between these curves depends largely on the rigidity of the steel sleeve and is illustrated for the two extreme conditions.

Curves indicate that the interference fit between the bearing and housing directly affects the force to move the outer race. The force to slip the bearing axially is about 30 percent greater than the force to rotate the bearing. This difference is attributed to the fact that while the bearing is being moved into the housing, the volume of the elastic decreases directly under the bearing and causes a volume increase behind the bearing. As shown in Figs. 1 and 9, the housing is undercut in order to partially relieve this condition.

Design Procedure

With the curve in Fig. 8, it is possible to obtain the necessary interference fit and to find the retaining force for bearings of any size without the test fixture (see Fig. 3). The steps to be followed are:

1. Find the peripheral area (which is under static pressure) $A = \pi\ w\ D$ where w is the length of housing in contact with elastic member, D is the bearing diameter plus twice the thickness of the steel sleeve.
2. Unit static bearing pressure can be determined from Fig. 8 based on the radial interference fit of the elastic.
3. From items (1) and (2), the total static pressure for any interference fit can be found.
4. The restraining force can be calculated by means of the equation given on Fig. 8.

Using this procedure, the results come within reasonable limits of the average of the experimental values. The calculated deflection curves are lower for larger bearing sizes compared to the actual measured curves. This might be due to the fact that as the unit pressure increases, the sleeve around the bearing yields slightly (in

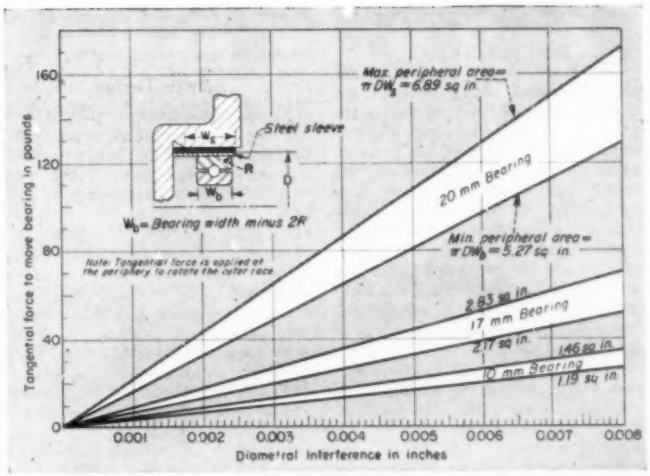

Tangential force to move bearing in pounds
Diametral interference in inches
Max. peripheral area = πDW_b = 6.89 sq in.
Min. peripheral area = πDW_b = 5.27 sq in.
20 mm Bearing
17 mm Bearing
10 mm Bearing
2.83 sq in.
2.17 sq in.
1.46 sq in.
1.19 sq in.
Steel sleeve
W_b = Bearing width minus 2R
Note: Tangential force is applied at the periphery to rotate the outer race

Fig. 7—Force required to slip or rotate outer race in its elastic support depends on the interference fit and effective elastic peripheral area. Actual values lie between curves shown which are based on maximum and minimum peripheral area.

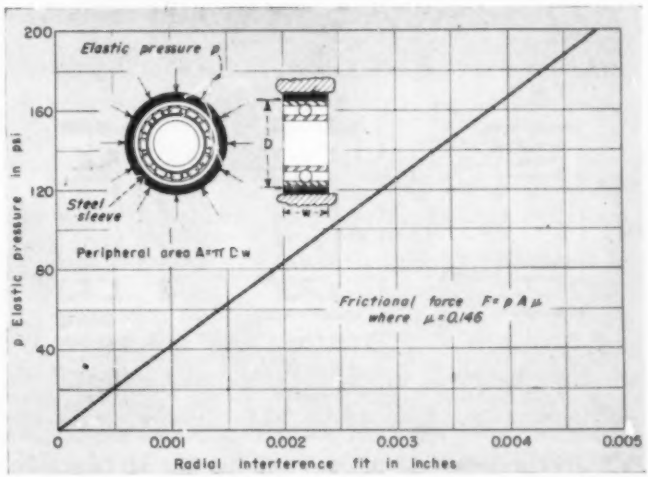

p Elastic pressure in psi
Radial interference fit in inches
Elastic pressure p
Steel sleeve
Peripheral area A=π D w
Frictional force F = p A μ
where μ = 0.146

Fig. 8—Radial interference fits are found from this graph and using the formula above to calculate the restraining force. Curve agrees closely with R = 2.5 (Fig. 4.)

regions not supported by the bearing), thus, giving a false pressure area.

Details of Design

When extremely wide bearings are used it may be found advantageous to add a groove at the center of the housing to facilitate the assembly. This construction is illustrated in Fig. 9(A). Such a modification for wide bearings does not materially affect the basic pressure deflection curve, but does decrease the force required in assembly. In other cases, two separate strips of elastic assembled as shown in Fig. 9(B) will accomplish the same purpose since the bulge-area ratio R is decreased.

When the load deflection will permit a smaller pressure area, the elastic member may be made narrower than the split steel sleeve. In this design, Fig. 9(C) the radial and axial forces more closely coincide. Such grooves serve as a seat for the elastic in the housing and must be wide enough to permit normal flow of the elastic material under the compression of assembly.

For applications which have appre-

ciable thrust loads, the use of Belleville springs are used to limit the axial motion. See Fig. 9(D).

The shape of the elastic strip can also be altered. Some methods are shown in Fig. 10. Besides the rectangular strip (A), the strip may be notched out to decrease the pressure to bulge area ratio. This reduces the initial force to get the bearing into its housing but does not appreciably change the basic curve. Bonding the elastic member to a thin steel sheet (C) reduces the problem of handling separate strips. This design is more costly because of the greater control required to maintain the effective thickness of the elastic which changes as it is curved to fit the housing. Bonding segmented metal (D) is an improvement from the standpoint of stretch and section reduction, but is more expensive.

Elastic rings fitted into a groove in the housing without the steel sleeve have been tried without complete satisfactory results, and modifications using a wavy spring with molded elastic have apparently been used with some success by other organizations.

Service Testing

This design was subjected to a year's life test before units equipped with the resilient-mounted bearings were released for production. These tests included many units ranging in size from 1/6 hp motors to 1.5 KVA motor-generator sets. The loads applied included fan loads, belt loads, coupling loads, and induced vibrating and centrifugal-force loads. These units (now 3 years old, and in many cases having more than 22,000 hours of service) have a perfect record with no failures of the resilient mount or other failures attributable to it, under normal operating conditions. The vibration was so severe on some of the units (where an eccentric load developed 118 lb centrifugal force) that rewelding of the base was required after 8 hours operation. In this case the resilient bearing mounting had over 4,000 hours life; this record has been exceeded by improved units undergoing the same severe test. When this construction is subjected to such severe tests, a retaining ring is necessary to limit the axial movement of the elastic member due to the kneading action of the unbalanced forces. In such abnormally severe service, if the axial movement of the elastic member is not limited, it will work its way out of the housing even though it is under considerable compression. The retaining rings are not necessary and are not recommended for ordinary service conditions.

The units on many applications in the field have been closely watched. Disassembly of such units show no wear of the split steel sleeve of bearing. In fact, the bearings generally show the mark of the gap in the steel sleeve, indicating that no relative movement has taken place between the sleeve and the bearing. The elastic member in all cases has been in perfect condition, showing no deterioration.

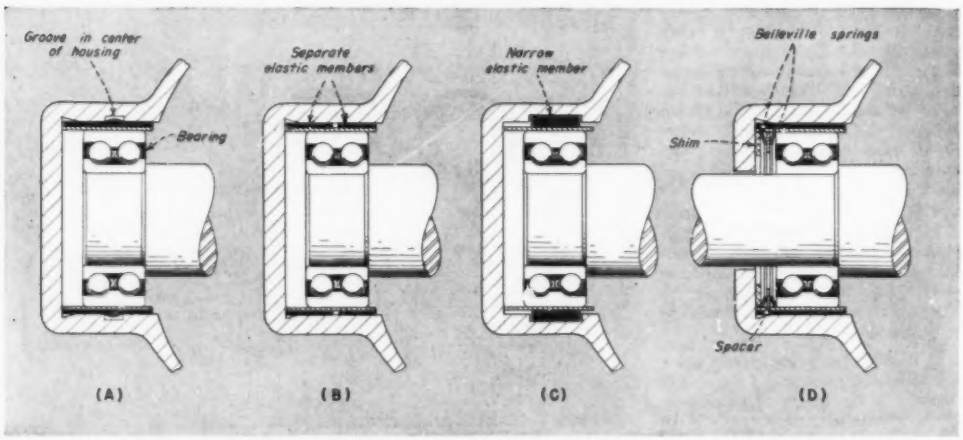


Fig. 9—There are several other ways to apply the resilient element for supporting ball bearings besides the design shown in Fig. 1(B). These details apply particularly for wider bearings. (A) Center groove serves to retain elastic. (B) Separate elastic strips and, (C) narrow elastic member lower the bulge area ratio *R*. (D) Belleville springs limit axial movement.

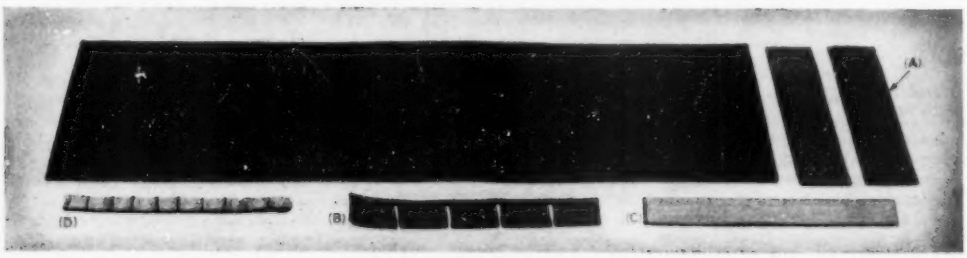
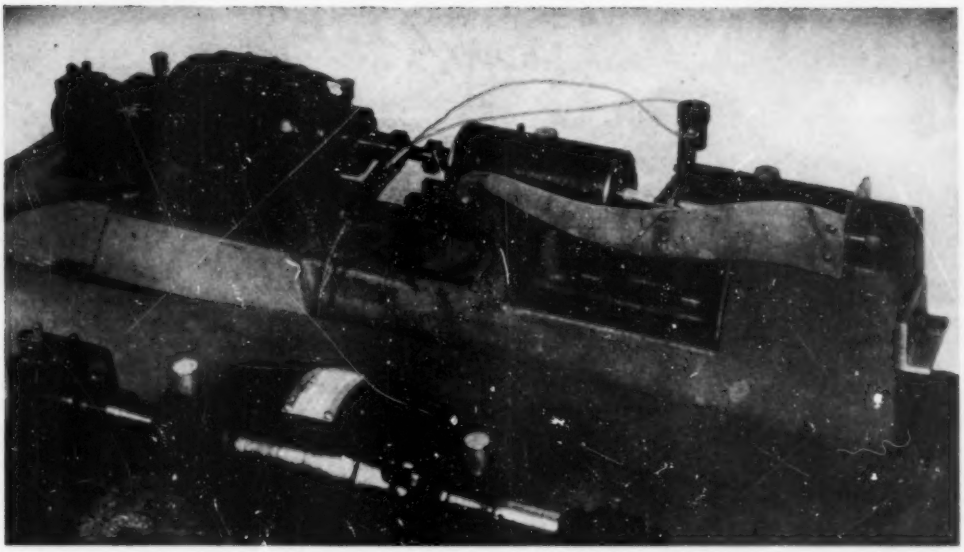


Fig. 10—In its simplest form, strips of sheet neoprene (A) are used to support bearings. (B) One way to decrease the bulge-area ratio and lower the force for assembly is by notching. (C) Bonding of the rubber eliminates the separate steel ring but is more expensive. (D) Segmented steel backing bonded to the rubber strip is another type of elastic support.

TECHNICAL NEWS



DEFLECTIVE-RESPONSIVE STOPPING DEVICE consists of a microswitch (center) actuated by a lever that is fastened to the bearing box of a standard testing machine. It is being used along with a vibration-responsive stopping device described below.

New Devices Speed Metal Fatigue Tests

NEW AUXILIARY TEST EQUIPMENT proving valuable in speeding metal fatigue tests at the National Bureau of Standards includes devices for stopping the testing machine when a small crack forms in a specimen, apparatus for the uniform polishing of fatigue test specimens, and a machine for fatigue-testing thin sheet specimens in bending.

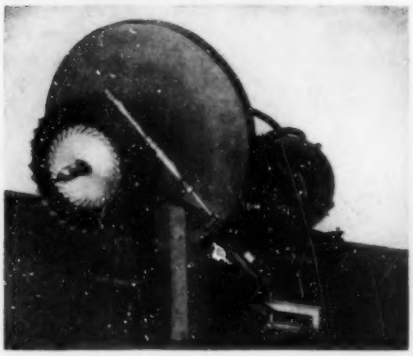
The stopping devices are designed for use with testing machines in which a specimen of 0.25 in. minimum dia is drawn into spindles in bearing boxes. The bearing boxes are supported at the ends away from the specimen and loaded at the ends near the specimen by weights hung on shackles. This loading results in a deflection of the bearing boxes which increases when a crack forms in the specimen. If the crack is only on one side of the specimen, the deflection will vary periodically with each revolution and the bearing box will vibrate. Both the deflection and the vibration are used to actuate the NBS stopping devices; one device is deflection-responsive and the other is vibration-responsive. The two are used simultaneously, with their circuits connected in parallel; sometimes one will respond first, sometimes the other, depending on the peculiarities of the particular incipient crack.

The deflection-responsive stopping device consists of a microswitch operated by a lever. The lever is fastened rigidly to one of the bearing boxes, and at the other end carries an adjusting screw which bears on the actuating leaf of the micro-switch. After the machine has run long enough to reach temperature equilibrium, the adjusting screw is advanced until a very small change in the position of the lever will trip the microswitch and shut off the machine. With careful adjustment, the arrangement is sensitive to cracks having a length of as little as 5 to 10 percent of the circumference of the specimen.

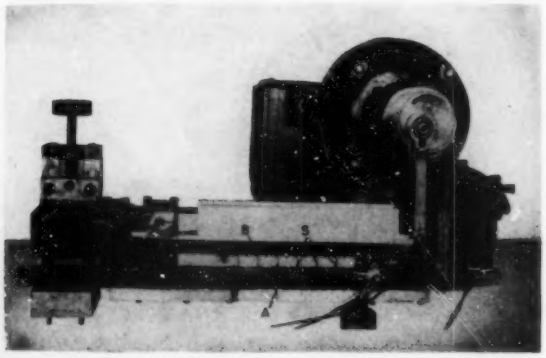
The vibration-responsive stepping device, which is fastened rigidly to one of the bearing boxes, consists of a steel ball poised on a three-pronged pedestal. Vibration resulting from an incipient crack in one side of the specimen shakes the ball from its perch; in falling, the ball closes an electrical circuit that shuts off the machine. Sensitivity of the device may be adjusted by varying the distance between the two pedestal prongs.

For finishing smooth fatigue specimens the machine consists essentially of three parts: a wheel carrying an abrasive belt; a means for supporting and rotating the specimen during the polishing operation; and a means for moving the specimen across the abrasive belt during polishing. The wheel is made of a large number of metal spring leaves, radiating outward from a hub, which press against the abrasive belt. This arrangement conforms the abrasive belt to the contour of the specimen and assures uniform abrasive pressure. The specimen is rotated at a rate which bears a constant relation (1 to 100) to the rotation of the abrasive wheel. Because the specimen is moved slowly across the belt, fresh abrasive is continually brought into use, resulting in a cutting rather than a rubbing action. Rubbing is to be avoided, since it is cold work to the specimen.

The apparatus for finishing notched specimens is new only in a few details. It consists essentially of an abrasive-charged wire which rotates against the bottom of the notch while the specimen is slowly rotated. The specimen is held in a small bench lathe. A series motor, mounted on the cross-



MOTORDRIVEN POLISHER for smooth fatigue specimens produces uniform finishes on all test samples.



THIN SHEET METAL SPECIMENS (S) are loaded as columns by the upper arm (B) which is moved vertically by the adjustable eccentric.

feed guide with its axis of rotation perpendicular to the axis of the specimen, drives the polishing wire through a short rubber coupling. A guide for the polishing wire is supported by a pivoted assembly above the working area, so that the weight of the guide holds the wire against the specimen. The abrasive, a thin air-agitated mixture of emery and water, is fed to the wire from a reservoir through a valve-controlled tube. The motor that drives the polishing wire also drives the headstock of the lathe through a 100 to 1 reducing gear.

Because sheet metal of less than about 0.015 in. thickness cannot be fatigue tested on cantilever type machines, the new tester loads each specimen as a column. Adapted from a Krouse Plate Bending Fatigue Machine, it loads several specimens simultaneously.

Samples (S) 1 in. high by $\frac{1}{4}$ in. wide are held in place by grooves in two horizontal arms, A and B, as shown. While the lower arm remains stationary, the upper arm, pivoted at one end, is moved up and down at the other end by a crank arm and adjustable eccentric. At the top of the crank throw the arms are parallel, and the distance between the grooves equals the length of the specimens. When the upper arm is lowered, the specimens are loaded as columns and assume bowed positions.

An automatic stopping device used with the machine takes advantage of the fact that after a crack forms, the specimen no longer deflects in a smooth curve. An adjustable contact assembly is clamped to the lower arm of the machine and adjusted so that the intact specimen nearest the crank just fails to touch the contact disk at its maximum deflection. Cracks tend to form near the center of the specimen, and when a crack starts, a "hinge effect" causes the middle of the specimen to deflect more and make contact with the disk. This contact operates a relay, stopping the machine.

When a group of specimens are set up in the machine, the one nearest the crank will break first. After it has been removed, the contact assembly is moved to the next specimen and the machine restarted. As many as seven specimens can be tested at once.

New Ceramic Coating For High Temperature Uses

A NEW PROCESS that can save the nation tons of scarce strategic materials by coating metals with ceramics has been announced by Solar Aircraft Company. It consists of new types of ceramic coatings, applied either by spraying or dipping, that are extremely thin and strong, and able to withstand intense heat and corrosive action. Importance of the process to national security has caused details to be kept secret.

Chief military value of the process is that treated aircraft engine parts are able to withstand extremely high temperatures without oxidizing or corroding. Most ordinary metals, when exposed to the heat of a jet engine, for example, rapidly disintegrate. As a result, engine makers have been forced to use expensive alloys made of scarce elements such as nickel, chromium, cobalt, tungsten and columbium in producing parts for jet, turbo-prop and other types of aircraft power plants. With the Solaramic Process it is possible to get equal service and life from metals that are less expensive and less scarce because the coatings improve the fatigue properties and strength of the metals. Specific surfaces, smooth or rough, heat reflecting or heat absorbent, acid resistant, etc, are possible, and the coating can be used to cover all kinds of welds.

The process includes a number of different ceramic mixes for use under varying conditions. While the coating is extremely strong, it is much thinner than other ceramic coatings and can be heated or cooled rapidly without cracking or flaking. In some applications the coating actually expands and contracts with the metal. For most applications a single coating is adequate.

Pitch Diameter Bolts Vs Full Body Bolts

REDUCED OR PITCH DIAMETER BOLTS of the machine, carriage or plow types offer savings in cost as well as better stress distribution when compared to full body bolts. This conclusion is based on data compiled by the International Harvester Company for the 1950 season. A savings of $68,459 in material, labor and tooling costs was reported with the use of 53,098,262 pieces. The static mechanical strength as given by tensile tests of representative samples of both the full body and pitch diameter bolts, in sizes $\frac{1}{2}$ in. and under, made of low carbon steel for which the static mechanical properties are in accordance with SAE Grade 2 indicate that the pitch diameter bolts are comparable, if not superior to the larger body ones. The pitch diameter bolts in some cases were more ductile

in the load range between the yield strength and the point of ultimate failure. Test data was obtained from six progress reports on bolts purchased from various manufacturers.

Disadvantages of using the pitch diameter bolts include: (1) the use of less stock for upsetting the head which requires greater care in heading and selecting the material; (2) loose fit in certain instances where the hold diameter in parts is not adjusted. The use of an underhead shoulder can eliminate this objection in many cases.

Radioactive Tires Used In Wear Tests

RADIOACTIVE PHOSPHORUS is being used in special tires by rubber research scientists conducting tests to determine tread wear. This new method, developed by the B. F. Goodrich Research Center, has the advantage of giving instantaneous data and enabling the evaluation of such factors as the type of road surface, temperature, speed, tire pressure and transmission of power on tread wear.

Radioactive phosphorous was obtained from the government's Oak Ridge Laboratories and immediately mixed into the compound for the top layer of the tread material for the special tires.

Wear data is obtained by using a portable Geiger counter mounted on a small cart to scan the track made by a radioactive tire. X-ray photographs of the "hot" tire tracks measure accurately the amount and size of the particles worn off the tire. In addition, a sheet metal air scoop behind the tire and two inches above the road measures the amount of rubber blown into the air. The scoop tapers into a standard vacuum cleaner hose where a paper filter traps the minute rubber particles. Their radio-activity is measured in the laboratory.

Military Truck Now Equipped With Hydra-Matic

A NEW MILITARY 6 x 6 TRUCK with Hydra-Matic drive, the M-135, is now going into mass production at the GMC Truck and Coach Division.

The new model, is bigger, faster, lower, easier to drive, easier to maintain and able to carry heavier loads than its predecessor of the last war. Powered by a new 6 cylinder (302 cu in.) engine, developing 145 hp, the 6 x 6 (meaning six wheels, all six power-driven) hits a maximum speed of 58 miles per hour carrying a 10,000 pound load. It also is equipped with "snorkel" devices for traveling submerged in water on deep-fording operations. As well as being waterproof, the 24 volt electrical system is dustproof, fungus proof and suppressed against radio interference.

Most radical development that has been built into the new super-truck, however, is the Hydra-Matic transmission with eight speeds forward and two in reverse. The Hydra-Matic operates through two gear ranges, a high and low, providing a combination that relieves the driver of all discretion in connection with gear selection except for shifting between the high and low ranges. The entire transmission control and the selection for automatic front-wheel drive engagement is accomplished by one lever on a knee-high tower within the cab.

Automatic front wheel drive engagement, an innovation designed to have the proper relationship between the front and rear axles, occurs in the transfer case to provide extra traction when needed. The front axle is free-rolling in highway service at which time power is delivered only to the two rear axles. When the truck hits rough terrain power is automatically applied to the front wheels when the rear wheels lose traction.

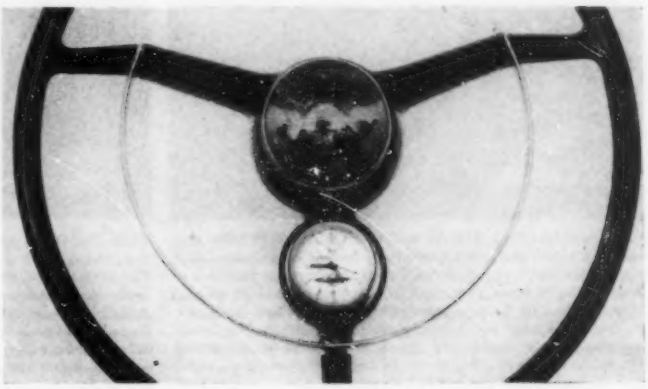
Another important feature is the use of torque rod suspension for the front axle in combination with regular leaf springs, which provides greater riding comfort for the driver and faster speeds over rough terrain. Rear springs also have been changed. A fixed secondary spring was added over the articulated main spring. The secondary spring helps carry the load and permits the truck to be overloaded without highly stressing the main spring or reducing riding clearance.

Finaliy—A Self-Winding Car Watch

AN ACCURATE 15 JEWEL CAR WATCH, available as optional equipment on 1951 Oldsmobiles at extra cost, has a self-winding Swiss movement that is produced with the precision of a personal watch. It is both shock-proof and anti-magnetic.

Mounted on the steering wheel, the watch is kept wound by pendulum weights which are actuated by the turning of the steering wheel and the normal movement of the car. Five miles of city driving or 20 miles of open highway driving will keep the watch running for approximately two days. When the movement is fully wound, the timepiece will operate for nine days. Should the automobile be in a garage or storage for an extended period, it can be manually wound by rotating the bexel or flange around the face counterclockwise. It is impossible to overwind the movement, either automatically or by hand. The hands of the Oldsmobile Car Watch are coated with luminescent paint, making them visible in the dark, and the protective lens is of non-breakable plastic.

An unusual feature is the red arrow on the watch face, which may be set at the departure time when leaving on a trip. In this way the driving time can be checked easily upon arrival at the destination.

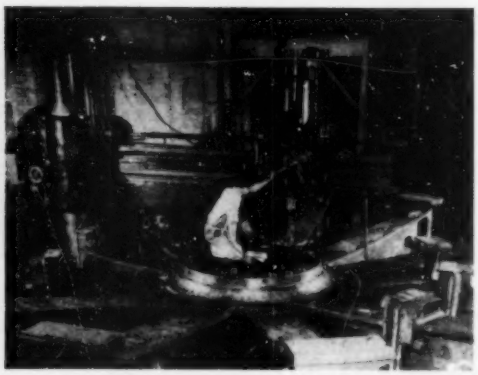


OLDSMOBILE'S NEW 15-JEWEL CAR WATCH has a Swiss movement that is produced with the precision of a personal watch. It is optional at extra cost.

DOUBLE-BRIDGE, MONORAIL, 3-TON CRANE at the General Electric Company has seven control functions; longitudinal and cross travel of the cab, rotation of cab and grab (360 deg), vertical travel of grab (floor clearance from 1 in. to 9 ft. 6 in.), tilting of grab (8 deg forward, 12 deg backward), rotation of forks and prongs (90 deg), and raising and lowering of prongs. This crane provides quick, efficient and selective handling of stock that consists of 12 shapes, 75 specifications, and 800 sizes. Other advantages include better housekeeping and a 50 percent reduction in the floor space requirements.

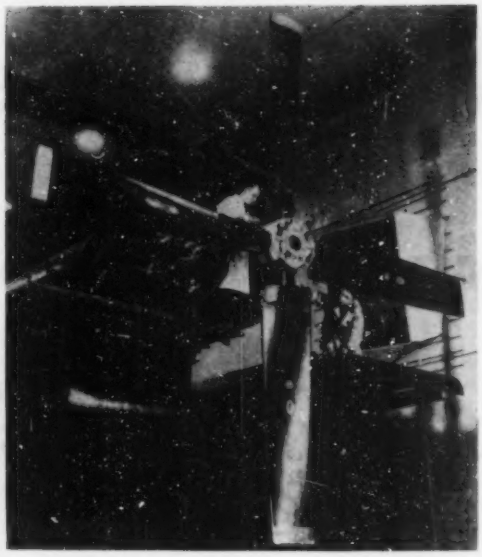
WORLD'S LARGEST COMMERCIAL RADAR ANTENNA, 40 feet wide, is part of a system built by Raytheon Mfg. Co., Waltham, Mass., for the Port of LeHavre, France. Antenna, which can operate in winds up to 100 mph, is shown in position for tests at Deer Island, prior to being shipped abroad. When installed, this system will provide a complete picture of all areas of a harbor, to vessels and shipping and port officials who are equipped with radar scopes. The pictures obtained in these tests were so sharp that small craft in the harbor, and every buoy and channel marker could be seen.

FOR ANALYZING THREE-DIMENSIONAL STRESSES that occur in pipe joints and threaded unions, U. S. Steel has added this polariscope to its National Tube Co. laboratory facilities in Pittsburgh. Fosterite, an olive drab, translucent plastic, is molded into the form of the pipe joint to be studied. When the plastic models are loaded and subjected to polarized light, the stress patterns become visiible and can be analyzed or photographed for study. If a Fosterite model is heated uniformly to about 100 C, loaded, and then cooled slowly, the stress pattern will become "frozen" and the model can be carefully sawed into pieces without disturbing the details of the stress pattern.



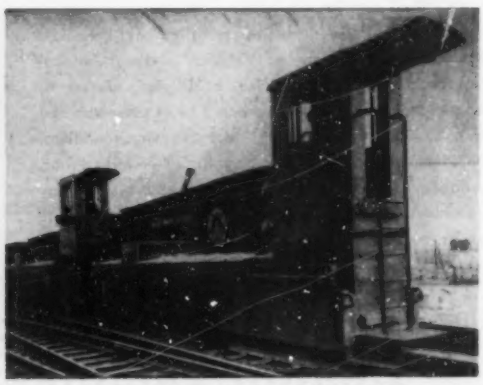
THIS 25-FOOT, 55-TON SPIDER will be the framework of the 215-ton rotor of a water-wheel generator being built by the Westinghouse Electric Corp. for the U. S. Corps of Engineer's hydro-electric project at Buggs Island, Virginia. The holes being drilled in the above illustration are for the large bolts that will fasten the rotor to the 34-ton shaft. The water wheel will be bolted to the other end of the shaft when the generator is assembled. Six of the spokes consist of two-piece assemblies. The end sections of these six spokes are bolted to the inner sections, and are removable to facilitate handling when the spider is ready to be shipped.

QUICK PICK-UP—Ten-ton coils of strip steel are handled easily and safely at Rouge plant of the Ford Motor Co. with these massive tongs especially designed for the job by Heppenstall Co., Pittsburgh. Remarkable delicacy in handling was imposed by Ford officials, as material has to be moved without damaging edges of the coil. Safety is assured during the operation of this equipment because the tongs eliminate the need for a ground crew to fasten and unfasten the load. The signalman shown in the illustration above is merely spotting a location for the craneman to use in unloading.



HOLLOW PROPELLER BLADES manufactured by Hamilton Standard are filled with a special Hycar base sponge rubber called HS160. Light, hard and strong, the sponge keeps the propeller blade shell from vibrating under pressures and supports it against the impact of rocks, ice and other material. Hycar, a product of B. F. Goodrich Chemical Co., is a rubber-resin foamed up to eight times its former mass. After foaming at a temperature of 300 F the compound cools into a light, rigid structure that fills the entire space between the propeller core and blade edges, and the hollow core itself.

THE DU MONT 30 IN. TELETRON, now being offered to both receiver manufacturers and to the trade for the first time, is the world's largest TV picture tube. The giant 30BP4 presents a usable picture area of approximately 536 square inches, or over twice the area of the 20 in. rectangular tube. It also incorporates many advanced features not found in other tubes. One is the short overall length of 23 9/16 in. achieved through the use of a 90 degree deflection angle. For maximum contrast as well as rejection of ambient light, the 30BP4 employs a DuMont gray-filter face plate. Sharp edge-to-edge picture focus is made possible by an exclusive gun design.



TWO GENERAL ELECTRIC 40-TON electric side-arm pusher locomotives in service on the Baltimore & Ohio Railroad, operate on a special narrow-gage track between standard railroad tracks. Power is supplied each unit's two electric motors by a 250 volt third rail. Pincer-shaped arms, which spring out on both sides of the locomotive and hook onto the freight cars, enable the units to move two lines of freight cars simultaneously when necessary. This special installation, part of a new import dock facility at Baltimore Harbor, Md., makes possible the unloading of a 30,000 ton ore boat in 24 hours by eliminating the time-consuming shuttling required with standard switchers.

ELIMINATE MOTOR FAILURE with class (H) insulation made with DOW CORNING SILICONES

Wet Motors

are a constant threat to your production schedules . . . unless they're wound with Dow Corning Silicone (Class H) insulation. Here's evidence of the fact that Class H has at least 10 times the wet insulation resistance of the next best class of insulating materials. At Virginia-Carolina Chemical Corporation's Homewood mine, a 300 hp., silicone insulated motor was back in service 3 hours after flooding with mud and waste water. Under the same conditions, an identical Class B motor had to be reworked and rebaked. Similar experience over the past 5 years has persuaded many chemical companies to specify Class H exclusively for all condensate and centrifugal pump motors.

Hot Motors

die young . . . unless they're protected with Dow Corning Silicone (Class H) insulation. Here's evidence of the fact that Class H insulation makes hot and hard working motors last 10 times longer than they ever did before. Silicone insulated spinner bucket motors in rayon mills last 6 to 24 times as long as Class A motors. Silicone insulation makes the high speed, rapidly reversing motors used by Cogsdill Twist Drill Company last 12 to 100 times as long as Class A or Class B motors. In a large steel mill, a crane hoist motor had 4 to 42 times the life of a Class B motor.

Note to electrical Design Engineers

There's a rapidly growing industrial and military demand for Class H equipment . . . the only kind that can withstand the toughest operating conditions. Write for Catalog No. R-9 listing Class H insulation components and specifications.

DOW CORNING CORPORATION, MIDLAND, MICHIGAN

FIRST IN SILICONES
DOW CORNING CORPORATION
MIDLAND, MICHIGAN

ATLANTA • CHICAGO • CLEVELAND • DALLAS • LOS ANGELES • NEW YORK • WASHINGTON, D. C.
In CANADA: Fiberglas Canada, Ltd., Toronto • In GREAT BRITAIN: Midland Silicones, Ltd.

Dimensional Tolerance Charts for Helical Springs

C. H. SACKS
Hunter Spring Co., Lansdale, Pa.

TO THE DESIGNER, specifying tolerances is frequently a more difficult problem than finding the nominal proportions of a spring such as the length, coil diameter and load which are usually dictated by the space available and pressure desired. Too often dimensional tolerances are considered a routine and meaningless procedure. However, tolerances closer than normal manufacturing variations and lower than those required for the specific application can unnecessarily increase the cost of springs.

The criteria for tolerances are: (1) normal manufacturing limits of the machine, and (2) allowances of the particular application. Specifying tolerances closer than normal manufacturing variations can only be achieved by 100 percent inspection and sorting to obtain those which are within the limits stipulated. This procedure raises the cost and should be used only when necessary. The designer should first verify whether normal tolerances will serve his purposes and remember that when no tolerances are indicated he automatically receives those tolerances based on machine capabilities.

To assist the designer in finding whether tolerances from normal manufacturing procedures will serve his needs, charts have been prepared based on springs manufactured over an extensive period. These charts should simplify his task in determining whether special springs at correspondingly higher costs are required.

COMPRESSION SPRING

Example: For spring in Fig. A, find:

1. Free length tolerance, ΔH
2. Mean coil dia tolerance, ΔD
3. Load variation, ΔP

In Fig. 1 with D/d of 6.6 and N/H of 8.0, Line I gives ΔH as 4.4 percent or ± 0.132 in. From Fig. 2, Line II indicates that ΔD is ± 0.005 in.

To find the load variation, ΔP at the specified length, Eq (1) in Fig. 3 must be solved. From this equation, ΔP is seen to be dependent on the individual

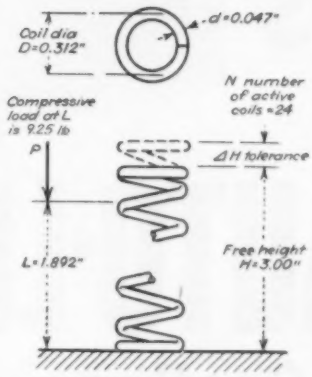


FIG. A

factors that exist in manufacturing springs: wire size, mean coil diameter, number of coils, and the variation in free length. These factors can be found from the graph in Fig. 3: with d of 0.047 in., X is found to be 0.00105 (Line III); with $D/d = 6.6$, Y is equal to 0.0011 (Line IV); having $N = 24$ turns, factor Z is 0.0004 (Line V). The fourth term under the radical is calculated to be:

$$\left[\frac{\Delta H}{H-L}\right]^2 = \left[\frac{0.132}{3.000-1.892}\right]^2 = 0.0143$$

Solving Eq (1):

$$\Delta P = 9.25\sqrt{(10.5+11+4+143)\times 10^{-4}} = \pm 1.20 \text{ lbs. or } \pm 13 \text{ percent}$$

EXTENSION SPRING

Example: With spring in Fig. B, find:

(1) Free length tolerance, Δb
(2) Mean coil dia tolerance, ΔD
(3) Load variation, ΔP

For close-wound extension springs where the coils are in contact with each other, the free length tolerance depends only on the variations in the wire size (assuming that the hook length is constant). In this case Fig. 1 is not required and standard practice is to specify the variations in free length as 2 pe.cent of the body length b. Therefore Δb is ± 0.019 in.

From Fig. 2, ΔD is found to be ± 0.0024 in. (Line VI). The load variation in extension springs, is determined from Eq. (2) and nomograph in Fig. 4. This equation differs from Eq (1). In Extension springs the initial tension P_I and the initial tension factor ΔI must be considered: From the nomograph of Fig. 4, this factor ΔI is 0.07 (Line VII); the other factors are obtained from Fig. 3. Thus, with music wire d of 0.024 in., X is 0.0014; having D/d of 6.8, Y is 0.0012; and the terms,

$$\left[\frac{0.02\times h}{L-H}\right]^2 = \left(\frac{0.02\times 0.943}{1.307-1.156}\right)^2 = 0.0158$$

$$\left[\frac{\Delta I\times h}{L-H}\right]^2 = \left(\frac{0.07\times 0.943}{0.151}\right)^2 = 0.191$$

Finally, from Eq (2):

$$\Delta P = (1.734-1.281)\times \sqrt{(14+12+158+1910)\times 10^{-4}} = \pm 0.207 \text{ lbs. or } \pm 11.9 \text{ percent}$$

(Continued on page 201)

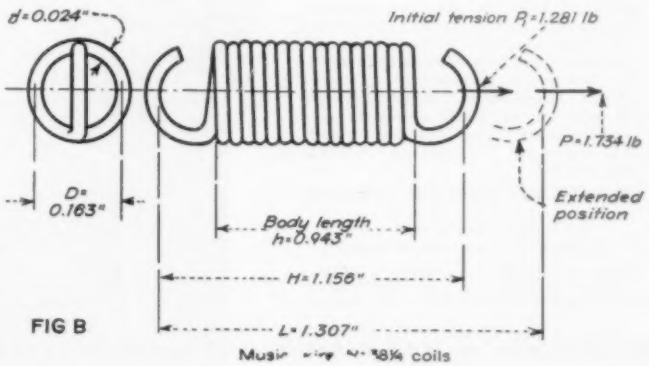


FIG B

You're always right with AUTO-LITE Die Castings

● Many of America's leading manufacturers, producing a wide variety of products, are benefiting from Auto-Lite die cast research, experience and advancement. Such developments as high pressure casting, special alloying practices and improved quality through the "controlled metals process" make Auto-Lite the logical source of supply for precision die castings. Address inquiries to:

THE ELECTRIC AUTO-LITE COMPANY
Die Casting Division
Woodstock, Illinois
Lockland Division, Cincinnati 15, Ohio

600 So. Michigan Ave. Chicago 5, Illinois
723 New Center Bldg. Detroit 2, Michigan

Tune in "Suspense!"...CBS Radio Mons....CBS Television Tues.

DIE CASTINGS • WIRE & CABLE • PLASTICS • INDUSTRIAL THERMOMETERS

Dimensional Tolerance Charts for Helical Springs (continued)

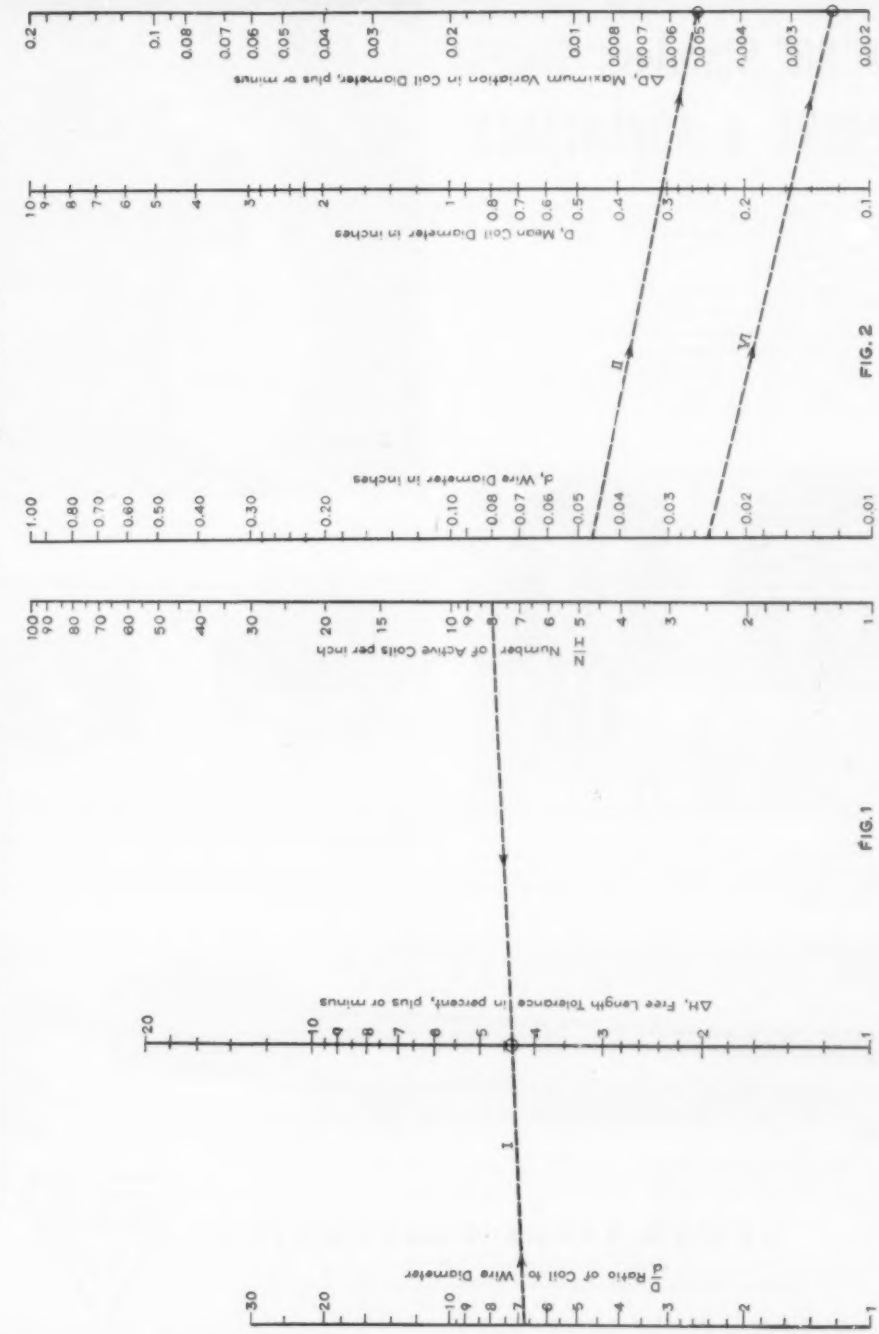

ΔH, Free Length Tolerance in percent, plus or minus
D/d Ratio of Coil to Wire Diameter
Number of Active Coils per inch
d, Wire Diameter in inches
D, Mean Coil Diameter in inches
ΔD, Maximum Variation in Coil Diameter, plus or minus
II
VI

FIG. 1

FIG. 2

(Continued on page 203)

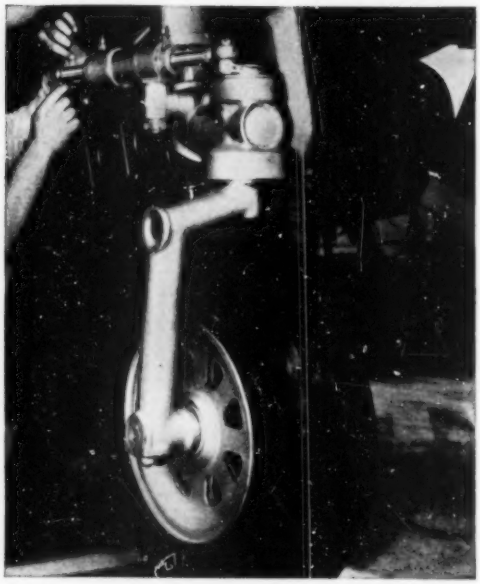
How "PH" Stainless Steels COMBINE 4 ADVANTAGES

Here are two Armco Stainless Steels that combine excellent corrosion resistance, high strengths and hardnesses with low-temperature heat treatments.

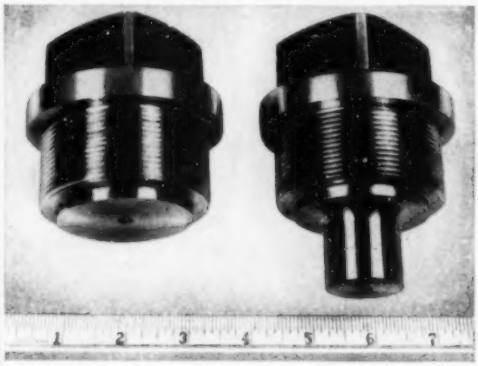
They are known as Armco 17-7 PH and Armco 17-4 PH.

These precipitation-hardening chromium-nickel types offer many new opportunities for the use of stainless steel, and are improved materials for many applications where standard stainless types are now used.

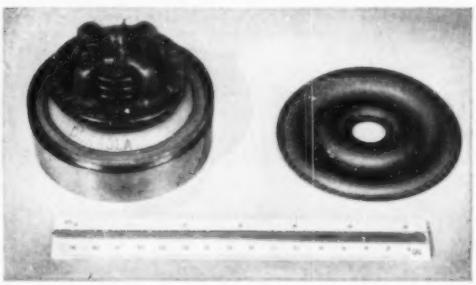
Depending upon condition supplied and subsequent heat treatment, Armco 17-7 PH sheets attain yield strengths of 150,000 to 250,000 psi and hardnesses up to Rockwell C50.



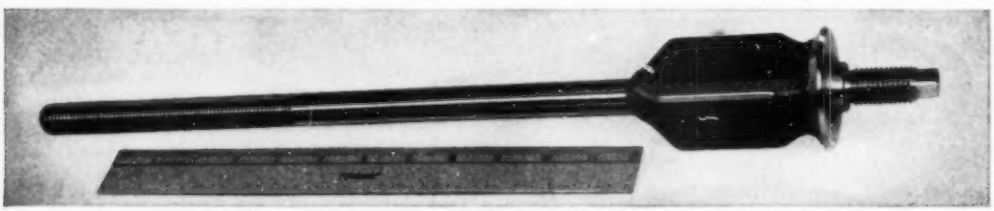
This anti-shimmy damper is one of the 13 production parts of Armco 17-4 PH bar stock used on AJ-1 and B-45 airplanes.



Armco 17-4 PH Stainless Steel bars are used for these valve plugs designed for pump heads in a chemical plant. Plugs are exposed to a solution of basic chromium sulfate at pressures ranging up to 7500 psi. Perfect threads are a "must."



For the best combination of high hardness and corrosion resistance, Armco 17-7 PH strip was chosen for the valve disc of this all-metal pump valve assembly.



Safety valve stem for liquefied petroleum gas tank made of Armco 17-4 PH. This part is upset and forged from bar stock, annealed and machined. Low-temperature heat treatment develops high yield strength without distortion.

ARMCO STEEL CORPORATION

4171 Curtis Street, Middletown, Ohio • Plants and Sales Offices from Coast to Coast • Export: The Armco International Corporation

ARMCO

MORE SCRAP MEANS MORE STEEL . . . TURN YOURS IN TODAY

Dimensional Tolerance Charts for Helical Springs (continued)

COMPRESSION SPRINGS

Load variation $\Delta P = P\sqrt{X+Y+Z+\left(\frac{\Delta H}{H-L}\right)^2}$ (1)

where factors: $X=\left(\frac{4\Delta d}{d}\right)^2$; $Y=\left(\frac{2\Delta D}{D}\right)^2$; $Z=\left(\frac{\Delta n}{N}\right)^2$

and can be solved by graph below.

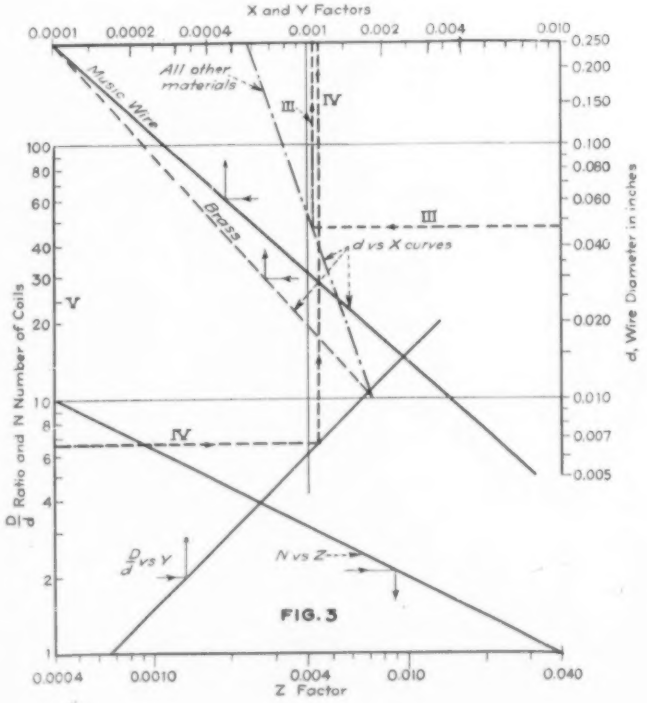


FIG. 3

EXTENSION SPRINGS

Load variation $\Delta P = (P-P_i)\sqrt{X+Y+\left(\frac{\Delta h}{L-H}\right)^2+\left(\frac{\Delta I \times h}{L-H}\right)^2}$ (2)

where X and Y factors are listed in Fig 3

and the $\left(\frac{\Delta I \times h}{L-H}\right)$ factor can be determined by graph below.

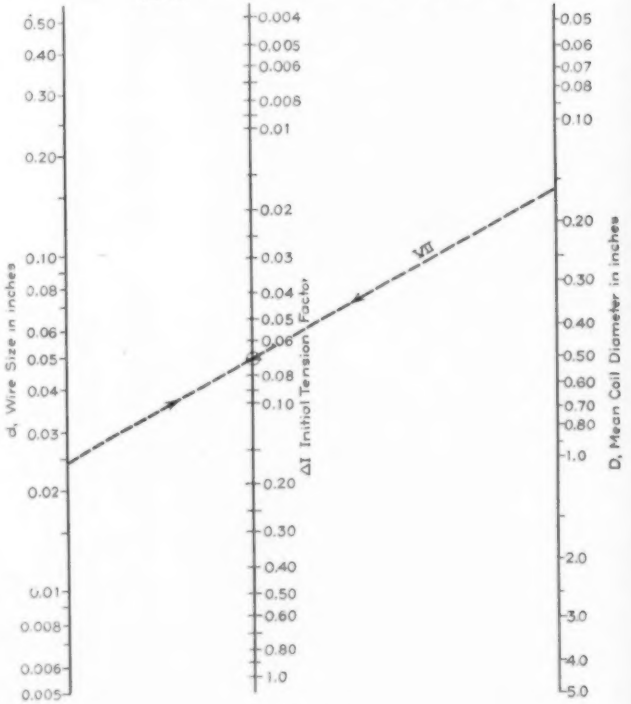
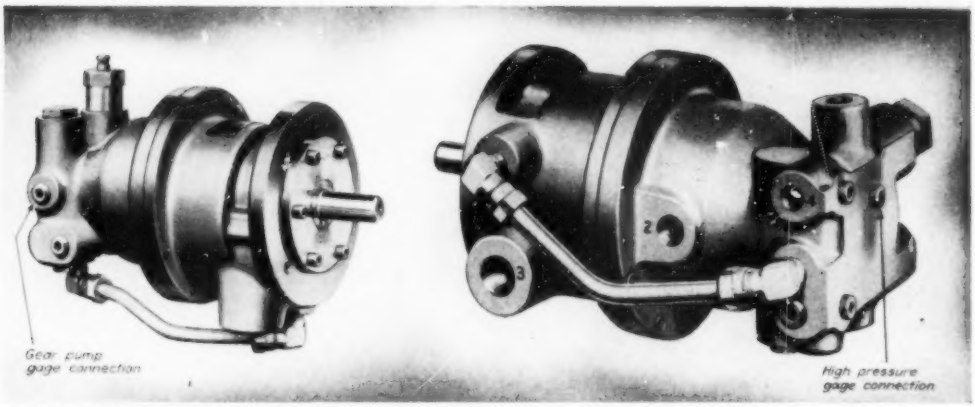


FIG. 4



WITH OIL TEMPERATURE AT 120 F, pressure at gear pump gage connection should be 100 psi. Adjustment of gear pump relief valve is accomplished by inserting or removing shims. Pressure is raised about 4 psi with the addition of each 0.010 in. shim. Pressure at the high pressure gage connection should be as shown on the chart. Pressure should be maintained in the pump.

High Pressure Pump Maintains Constant Delivery

The Oilgear Type "HG-830" pump is a constant delivery, axial piston unit with an integral supercharging gear pump, gear pump relief valve and high pressure relief valve. The maximum pressure developed by the piston pump is limited by the resistance of the work, the input power or by adjustable high pressure relief valve.

High grade oil of the hydraulic oil class serves as the fluid power and lubrication medium. It is drawn into the system by the gear pump through Port 3 and delivered by the piston pump from port 1. Relief valves exhaust out port 4. Port 2 is case drain.

Inside the pump a cylinder barrel is pressed on the drive shaft which rotates on two anti-friction bearings. Seven pistons, closely fitted in axial holes in the cylinder, are free to rotate and reciprocate therein. The convex ends of the pistons contact a bearing mounted swash plate which is at a fixed angle to the drive shaft. Radial and axial holes in drive shaft connect piston bores in the cylinder to pressure and suction ports through a crescent-ported flat valve thru suitable passages in the housing. Four springs, hollow pistons and tumblers in the case and two compensating pistons in the flat valve hold it against end of the shaft. A gear pump is fitted in the gear pump housing with a driver gear keyed to the drive shaft and a driven gear running on a stub shaft. The two reverse flow type relief valves are built into the pump case.

As shown in drawing, when the drive shaft is rotated, oil is drawn into the system by the gear pump and delivered through a tube and passages in the case, flat valve and drive shaft into the axial holes in the cylinder connected to the intake port of flat valve. As each piston reaches its outermost position, gear pump oil moves pistons outward against the swash plate during one-half revolution. When the swash plate forces pistons inward during the other half revolution oil below the pistons is delivered through shaft, flat valve and out port 1. Springs in the end of the case, combined with the hydraulic pressure on the back-up pistons and tumblers, hold the flat valve against the end of the drive shaft. Two compensating pistons in the flat valve balance the hydraulic forces tending to separate the flat valve from the end of the drive shaft. The pre-set relief valve limits the gear pump pressure and discharges the excess oil back to the reservoir. The adjustable relief valve limits the axial piston pump pressure.

Rotation of the standard pump drive shaft is clockwise when viewed from shaft end of pump. The drive used may be direct, belt, texrope, silent chain or gear. The coupling, pulley, sheave, sprocket or gear driver should be a slip fit over the shaft and fasten with set screw. Power is required in proportion to volume and pressure desired. Standard low starting torque motors are suitable for most applications. Motor recommendations for specific applications can be obtained from the manufacturer.

This pump is the first of three sizes now being offered. The performance specifications are shown in the chart. The external dimensions are identical and except for the drive shafts, flat valve, cylinder, pistons, pump case and high pressure relief valve spring, the working parts are interchangeable.

The pumps are available either with or without reservoirs. The ones equipped with reservoirs are fitted with tubes in ports 2, 3 and 4 before being mounted in place. The ones

MATERIALS - PARTS

SPECIFIED BY PRODUCT ENGINEERS

Motor Size, hp	Input Speed, rpm	HG-530			HG-830			HG-850		
		Max Press psi	Approx Cap at 3000 psi		Max Press psi	Approx Cap at 3000 psi		Max Press psi	Approx Cap at 5000 psi	
			cipm	gpm		cipm	gpm		cipm	gpm
3	710	3000	233	1.01	2115	410	1.77	3820	204	.88
3	860	3000	288	1.25	1680	505	2.19	3200	255	1.10
3	1140	2310	394	1.71	1185	690	2.98	2310	360	1.56
3	1450	1725	509	2.20	860	895	3.87	1725	471	2.04
3	1750	1370	620	2.68	660	1090	4.71	1370	580	2.51
5	860	3000	288	1.25	3000	505	2.19	5000	255	1.10
5	1140	3000	394	1.71	2200	690	2.98	4000	360	1.56
5	1450	3000	509	2.20	1650	895	3.87	3140	471	2.04
5	1750	2540	620	2.68	1310	1090	4.71	2540	580	2.51
7½	1140	3000	394	1.71	3000	690	2.98	5000*	360	1.56
7½	1450	3000	509	2.20	2640	895	3.87	4610	471	2.04
7½	1750	3000	620	2.68	2140	1090	4.71	3880	580	2.51
10	1750	3000	620	2.68	2950	1090	4.71	5000	580	2.51
15	1750	3000	620	2.68	3000	1090	4.71	5000	580	2.51

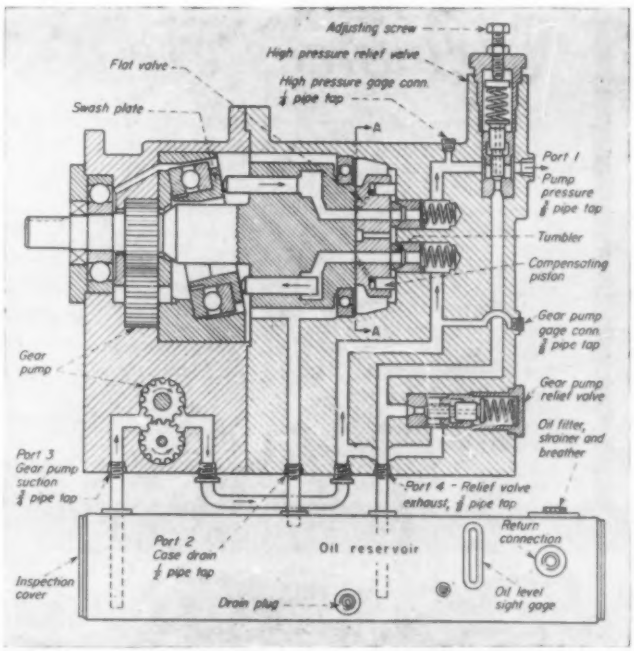
MAXIMUM PRESSURE FOR HG-530 and HG-830 pumps is 3,000 psi and for HG-850 pump 5,000 psi. All other pressures listed are the maximum limited by normal electric motor capacity. Relief valve on HG-530 and HG-830 pumps is adjustable from 600 to 3,000 psi and on HG-850 pumps from 1,000 to 5,000 psi. External dimensions are the same for all pumps.

not equipped with reservoirs have the tubes removed. Port numbers corresponding to ports on pump are stamped on tubes furnished by manufacturer.

Normal servicing of these pumps consists only of an occasional check of the reservoir. Since all moving parts are lubricated by the hydraulic oil in the system, provisions specifically designed for the application of lubricants from the outside of the pump are unnecessary.

These units are especially suitable for heavy-duty pushing, pulling, lifting and lowering and for maintaining high static loads on large clamping rams in the iron, steel, metal working, plastic, automotive, rubber, printing, lumber and textile industries.

HERE THE FLAT FACE VALVE is shown from the shaft side. The crescent shaped ports direct inlet and high pressure oil to and from the pump cylinder. The dotted lines show the position of the two compensating pistons and retainer.



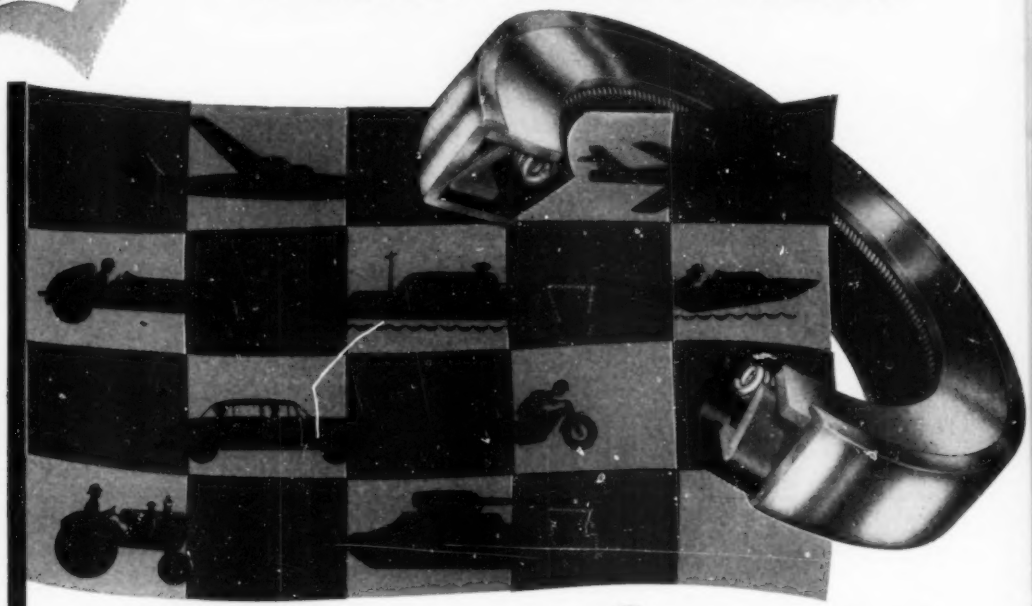
THE ABOVE SCHEMATIC DRAWING shows the oil flow thru the pump and the general layout of the component parts. Pumps are available with or without reservoirs.

The Oilgear Co., 1560 W. Pierce St., Milwaukee 4, Wis.

CONTINUED ON PAGE 207

C/R

PICK A WINNER



chances are it's C/R sealed

Winners in every field are protected with C/R Oil Seals. The cars, planes and boats "out front" demand perfect oil and grease retention, absolute bearing protection. That's why you'll find more motor vehicles, farm implements and industrial machines equipped with C/R Oil Seals than with any other shaft-type sealing device.

Behind this universal acceptance of C/R Oil Seals is a record of complete product reliability and a long-standing practice of "cooperative" engineering. In other words, when you have a tough fluid sealing or dirt exclusion problem, Chicago Rawhide engineers will work hand in hand with you to see that you find the "Perfect," dependable answer.

ENGINEERS: We will be pleased to send you engineering data on "Perfect" Oil Seals on receipt of your written request.

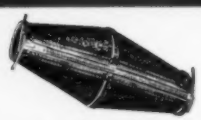
The result of 30 years' pioneering to solve difficult sealing problems is a vast assortment of types and sizes to suit the most critical demands of quality and performance. Today, in addition to specially developed seals for unusual applications, you may choose from 15 standard types and 1800 sizes.

When you specify C/R Oil Seals, you know you are getting the world's finest sealing device.

Chicago Rawhide engineering service is always available for the solution of your particular sealing problems.

CHICAGO RAWHIDE MANUFACTURING CO.

1299 Elston Avenue OIL SEAL DIVISION Chicago 22, Illinois



sirvis

Mechanical Leather Products

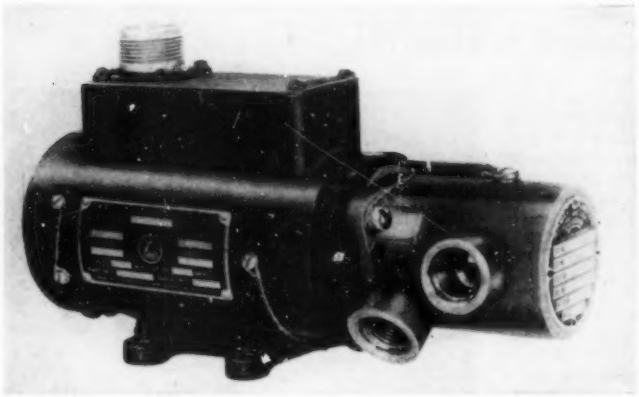
Boots, diaphragms, packings and other products give dependable service under difficult operating conditions.

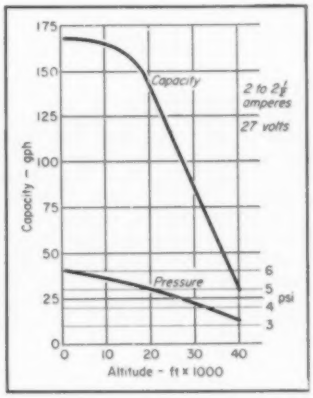
SIRVENE

The Scientific Compounded Elastomer

Custom-engineered and custom-built for critical service in aircraft, automotive and other mechanisms.

C/R PERFECT Oil Seals





Fuel Drain Scavenge Pump Has High Capacity

A specially built fuel pump used in the Boeing B-47 to remove all fuel from the manifold after a refueling operation, or transfer of fuel has been accomplished, is equipped with a 27 v d-c motor. The pump is designed to deliver at least 100 gph at 3,500 rpm, 5 psi discharge pressure at 17,000 ft altitude. Weight is 3.25 lb. Length of unit is 7 25/64 in.

The same pump is available with an a-c motor of 115 v 400 cycle; it has a capacity of 150 gph at 4,000 rpm and 5 psi pressure. Identification for this a-c unit is RG-9440.

These pumps are rotary vane type and have 0.179 cu in. displacement per revolution. No lubrication is required other than the fuel pumped. Graphitar blades and bearings permit dry operation. These pumps are self-priming.

Motors and pumps are suitable for operation under extreme temperature conditions. Mechanical shaft seal, and large seal drain port protect the motor. Motors are explosion proof, and are equipped with radio noise filter.

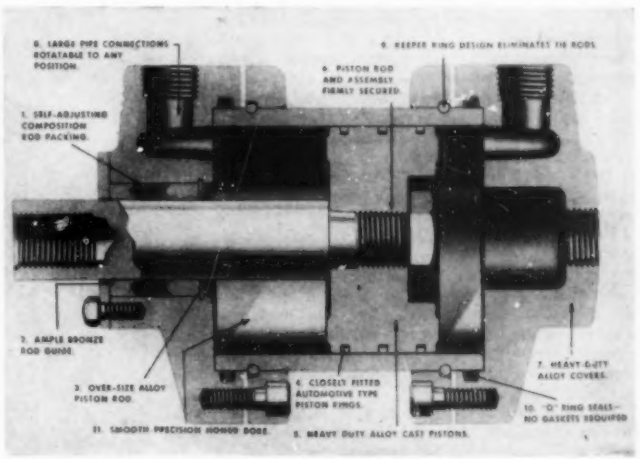
Lear, Inc., Romec Div., Elyra, Ohio

Hydraulic Cylinder Has Rotating Heads

The construction of this hydraulic cylinder allows the covers to be rotated for any pipe connection and installation made in a minimum of space. This is possible by the use of a keeper ring design instead of tie rods for holding the covers together.

External "O" rings, are used as static seals, to provide leak-proof operation. Sealing efficiency of the ring improves with increased pressure. Automotive type rings are used on the piston to reduce friction to a minimum.

Other features are: self-adjusting composition rod packing. Axial holes through rod bearing provide for pressure disposal on packing members; ample bronze rod guide. Rod bearing provided in area exposed to lubrication; heavy-duty alloy cast pistons with large bearing surfaces; seamless drawn steel tubing, piston rod and assembly firmly secured. Alignment assured by close-fitting pilot and shoulder; heavy-duty alloy covers large connections.


8. LARGE PIPE CONNECTIONS ROTATABLE TO ANY POSITION.
9. KEEPER RING DESIGN ELIMINATES TIE RODS.
6. PISTON ROD AND ASSEMBLY FIRMLY SECURED.
1. SELF-ADJUSTING COMPOSITION ROD PACKING.
2. AMPLE BRONZE ROD GUIDE.
3. OVER-SIZE ALLOY PISTON ROD.
4. CLOSELY FITTED AUTOMOTIVE TYPE PISTON RINGS.
7. HEAVY-DUTY ALLOY COVERS.
10. "O" RING SEALS—NO GASKETS REQUIRED
11. SMOOTH PRECISION HONED BORE.
5. HEAVY DUTY ALLOY CAST PISTONS.

Rivett Lathe & Grinder, Inc., Brighton 35, Boston, Mass.

CONTINUED ON PAGE 208

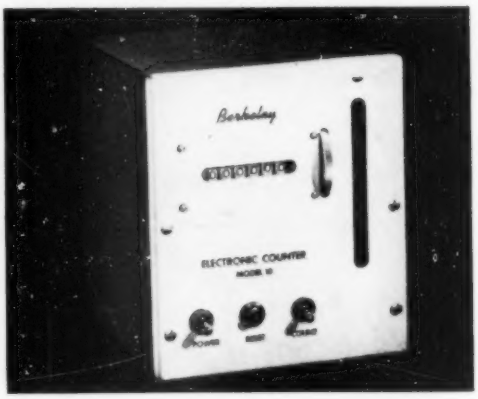
Electronic Counter Has High Capacity

Any mechanical, optical, or electrical occurrences that can be converted to electrical impulses may be counted at rates up to 6,000 per min. This instrument will differentiate between any two occurrences as close together as 20 microseconds. Therefore, large deviations in counting rate do not affect the absolute accuracy of this unit.

The instrument may be operated from any of the following sources: closing contacts: a source of potential is available on the rear of the instrument; photocell: the same source of potential is available on the rear of the instrument to operate a variety of standard photocells; voltage pulse: whenever the grid terminal of the counter has a positive potential of 2 v or greater applied to it, the decimal counting unit will register one count. The acceptance of the pulse is not dependent upon the rate of rise of the applied potential, therefore, a slowly varying voltage will trigger the unit.

The front panel controls consist of a power switch, a count switch, and a reset push-button. The instrument will accept counts only when the count switch is in the up position. It is placed in a standby position when the count switch is down. The totalized count will remain displayed on the decimal counting unit and the mechanical register until the reset button is pushed and the register thumbwheel rotated. Total capacity is 9,999,999 counts.

The instrument uses selenium rectifiers in the power supply, and all wiring has been moisture and fungus proofed to insure reliability and long operating life. All



circuits have been developed around one tube the 12AU7.

This counter is not affected by normal variations in the 117 v line potential and all counters are tested to insure proper operation over a line voltage range of 105 to 130 v. Power consumption is approximately 25 watts.

Berkeley Scientific Corp., 2200 Wright Ave., Richmond, Calif.

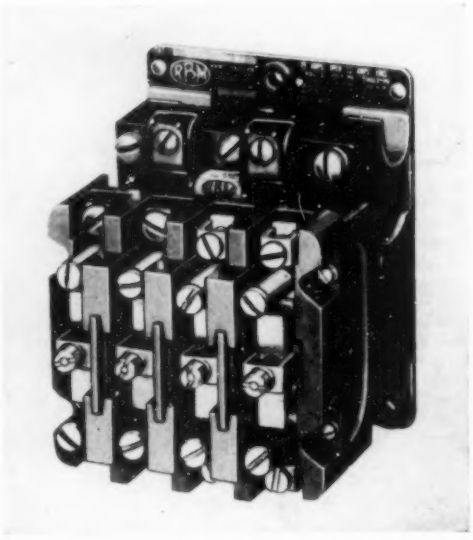
Industrial Capacitor Has 25 Ampere Rating

An industrial capacitor with a 25 amp rating and normally open contacts has recently been announced for use on machine tools, electric hoists, and other applications where dependable operation and compact design are essential.

Designed for operation at 600 v max on 25 or 60 cycles a-c, it is rated on polyphase connection at 3 hp on 110 v, 5 hp on 208 to 220 v, and 7½ hp on 440/550 v. On single phase, the ratings are 1½ hp on 110 v, 3 hp on 220 v, and 5 hp on 440/550 v. Initial contact pressure is 10 oz per pole; final contact pressure is 12 to 14 oz per pole.

This capacitor is available in 2 to 5 pole construction, reversing and non-reversing, open and enclosed. It has an E-type magnet and floating armature. Solderless terminals suitable for No. 6 wire are standard, but screw terminals can be furnished on special order. The steel base with neoprene mounted grommets permits mounting on a grounded service without further insulation, and the small overall size is said to permit side-by-side mounting with minimum space requirements.

The addition of the 5 pole 25 amp design to the standard line manufactured by this company permits complete mounting interchangeability between the 10, 15 and 25 amp sizes that are made in the 2 to 5 pole construction.

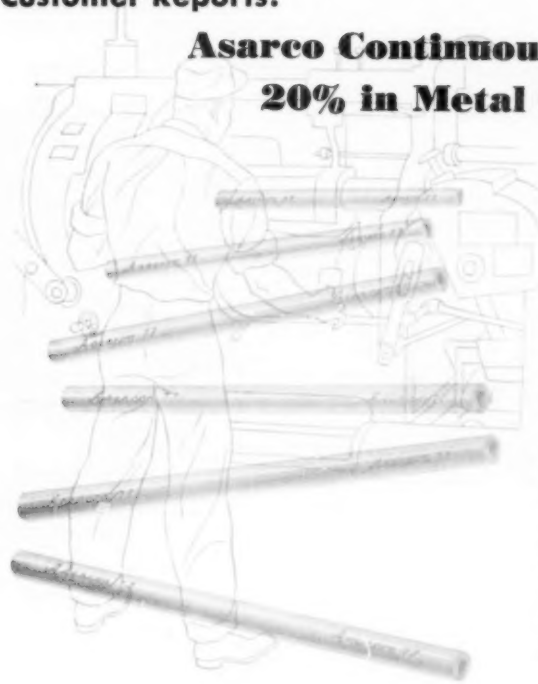


R-B-M Div., Essex Wire Corp., Logansport, Ind.

CONTINUED ON PAGE 210

Customer Reports:

Asarco Continuous Cast Bronze Saves 20% in Metal Cost, Production Time



A manufacturer of packaging machinery tells of saving 20% in production time and 20% in material cost when he makes shaft bearings and nuts of Asarco Continuous Cast Bronze.

The patented Asarco casting process guarantees him bronze rod that is free from the hard and soft spots so often found in sand cast bronzes. Stock is exceptionally uniform and free from porosity. Since sand is not used, and dirt and dross are excluded, there can be no surface or internally trapped abrasive to dull tools or discourage high cutting speeds. Rejects are virtually unknown.

Dimensions are held to extremely close limits. For example, tube concentricities are within 1.5% of wall thickness. Dimensional uniformity is assured . . . machining on automatics is standard practice.

Continuous Cast Bronzes can be made to order in a wide variety of alloys . . . in standard lengths of 12′ . . . lengths 5′ to 12′ on request . . . lengths 12′ to 20′ on special arrangement.

216 sizes of standard Asarcon 773 bronze (SAE 660) are stocked in 105″ lengths for convenience at warehouses in all principal cities. Distributors will cut this stock long or short to suit your needs.

ASARCO CONTINUOUS-CAST RODS-TUBES-SHAPES ®

Send for this free catalog on Asarco Continuous Cast Bronzes. It contains physical properties, table of weights, photomicrographs, table of stock shapes and sizes and other data.

West Coast Sales Agent:
KINGWELL BROS. LTD., 444 Natoma Street, San Francisco, Calif.

American Smelting and Refining Company

OFFICES: Perth Amboy Plant, Barber, New Jersey
Whiting, Indiana

Starter Works on Compressed Air

Two starting motors have been designed for use in the lumbering, petroleum, mining, marine, heavy construction and power fields. They are to be used for cranking diesel and gasoline engines with piston displacements up to more than 3,500 cu in. and may be operated by compressed air, or natural gas where available at sufficient pressure.

The advantages of these starters over equivalent electric starters are said to be that they are not affected by climate conditions and do not require generators or storage batteries.

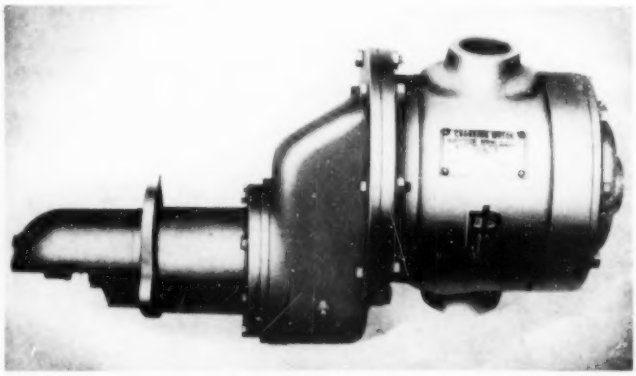
The housing of the air starting motor can be rotated on the gear case, or the gear case rotated on the motor bell housing to clear projections on the engine.

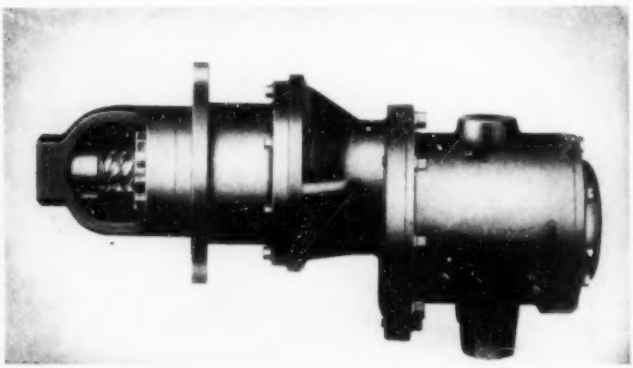
The starter consists of a Multi-Vane air motor which cranks the engine through a Bendix drive. The air motor consists of a solid, hardened steel rotor, revolving in a cylinder of hardened wear-resistant alloy, and enclosed by bronze end plates. The rotor has five vanes to insure a smooth flow of power. Ample-sized ball or roller bearings are used throughout.

The starters are available in two sizes: the Size 9BM, which develops up to 16 hp and requires approximately 7 cu ft of air per start; and the Size 20BM, which develops up to 41 hp and requires approximately 16 cu ft of air per start.

11 Broadway, New York 4, N. Y.
Ingersoll-Rand Co.

THIS EXPLODED VIEW OF AIR MOTOR shows the ball bearings, end plates, locating pins, cylinder, rotor and vanes. Ample sized ball or roller bearings are used throughout to support all rotating parts for long life and trouble free service.





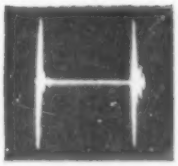
ABOVE IS SHOWN the large size starter which develops up to 41 hp and requires approximately 16 cu ft of air per start. The housing of the air starting motor may be rotated on the gear case or the gear case rotated on the Bendix drive housing to clear projections on the engine. Construction similar to internal combustion engines facilitates maintenance.

AT LEFT IS the small size starter which develops up to 16 hp and requires approximately 7 cu ft of air per start. The weight of this motor is 40 lb including the Bendix drive. The weight of the 20 BM model is 103 lb including the Bendix drive. Designed for use in any field, these starters are not affected by the climatic conditions injurious to electric motors.

CONTINUED ON PAGE 212

LEADERSHIP can't stand still

this time it advances on ultrasonic waves

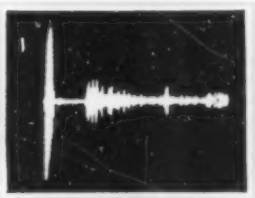


Because production isn't always perfect, inspection of all materials is essential to assure quality. When new inspection tools and methods have demonstrated their usefulness, they replace or supplement the old.

Nondestructive inspection *inside* the metal is now made possible through the Ultrasonic Reflectoscope. The American Brass Company has adapted its use to inspect large plates of copper alloys, thus making doubly sure that *hidden* defects are not present—defects which may appear in machining or forming operations and cause costly rejections.

In keeping with a tremendous mill-improvement program, the introduction of the Ultrasonic Reflectoscope in this industry is another indication of Anaconda's leadership in quality control in the field of copper and copper alloys. The American Brass Company, General Offices, Waterbury 20, Connecticut.

A1108



This is what happens:

Simple to operate, the portable Ultrasonic Reflectoscope sends intermittent high-frequency sound waves angularly into the plate. If unimpeded, the waves will reflect from the opposite edge of the plate and indicate a normal pattern on the screen of an oscilloscope, as illustrated opposite the headline.

Any hidden flaw or internal defect will result in a discontinuity of the wave and will be instantly evident on the screen, as pictured immediately above.

ANACONDA *the name to remember in* **COPPER and COPPER ALLOYS**

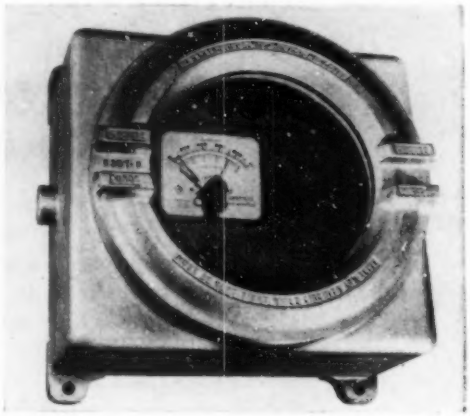
Explosion-Proof Pyrometer Control

Automatic controls in explosion proof housing now may be used in locations where there is a hazardous atmosphere. These instruments provide indication and control for industrial processes including temperature, speed, thickness and overload, and may be used for safety shutoff and warning devices in chemical and nucleonic operations.

The instrument shown is a double contact, thermocouple pyrometer with a temperature range of 0-1,000 F, 0-500 C. A bank of these is used by a chemical concern for controlling furnaces. In this particular application the material in the process may develop its own heat at certain stages.

The low limit contact is used for on and off control of the supplied heating power. The high limit contact is used as a safety shutoff to apply a corrective factor when the temperature starts to climb from internal energy.

Assembly Products Inc., Chagrin Falls, Ohio



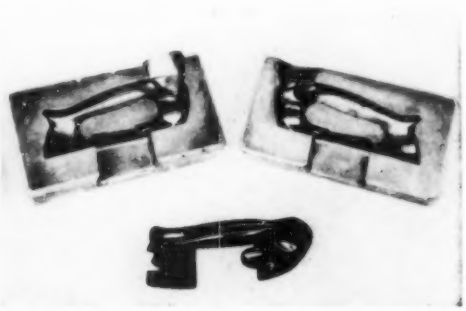
Hardening Time of Casting Resin Reduced

The development of a product called Quick-Set is said to allow resin castings to be hardened without heat at room temperature in a short period of time. This permits increased production of master models, duplicating and foundry patterns, and jigs and fixtures.

Quick-Set is a liquid accelerator which gives high physical properties to casting resins. When added to "8000" Tool-Plastic mix developed by this company, this formula eliminates the use of ovens and overnight hardening. Control of hardening time desired is made possible by increasing or decreasing the amount of Quick-Set used.

The duplicating pattern in the photograph was made and ready for use in one hour and 40 min by using Quick-Set with "8000" Tool-Plastic mix.

Rezolin Inc., 4825 W. Jefferson Blvd., Los Angeles 16, Calif.



Hard Copper Alloy Is Easily Formed

An unusual combination of physical and fabricating qualities are claimed for "Formbrite" copper alloy. Manufacture of this material involves a special procedure of rolling or drawing and annealing brass containing 63 to 90 percent copper to obtain the fine grain-size (about 0.008 mm).

Physically the metal is said to be stronger, harder and more resilient than ordinary drawing brass, yet retains remarkable ductility for deep drawing, forming and cold upsetting. Its harder surface tends to resist abrasion and scratching.

The fine grain structure of Formbrite is said to provide metal with a surface so smooth that a simple buffing operation produces a lustrous finish.

Sheet and strip manufactured by this method is offered for practically all drawing brass purposes. Because of its initial high strength and stiffness, cold fabricated parts acquire added sternght and stiffness and frequently can be made of thinner metal than if the usual deep drawing brass were used.

The physical properties for "Formbrite" of a composition and hardness comparable to standard 70-30 half hard brass are as follows: yield point, 39,000 psi.; tensile strength, 63,000 psi.; elongation in 2 in., 35 percent.

In the manufacture of wire products, Formbrite machines and threads with ease and is said to be ideal for rivets, wood and machine screws.

This copper alloy material can be supplied equivalent to ASTM specifications for either quarter or half hard stock. It is available in sheet, strip, wire, rod and tube forms.

The American Brass Co., Waterbury 20, Conn.

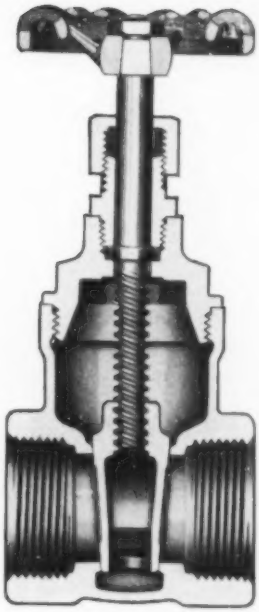
CONTINUED ON PAGE 214

Big help on Piping design ...your CRANE Catalog

Big help in more ways than one, too. Your Crane Catalog saves specifying time—everything you need is carefully cataloged and cross-indexed for quick and easy selection. And "everything" at Crane means the world's most complete assortment of valves, fittings, pipe, and piping accessories.

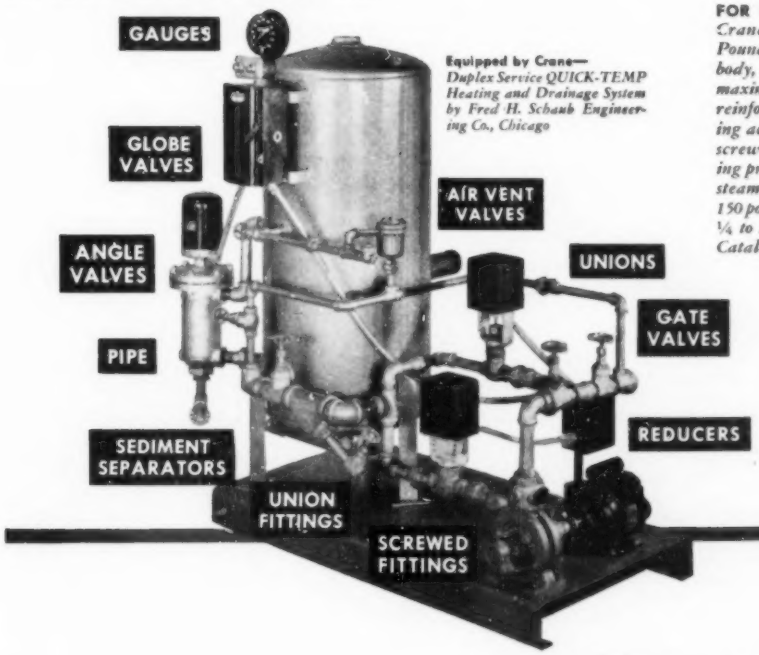
Making Crane your single source of supply simplifies other piping procedures, too—ordering, storekeeping, and final product assembly, for example. Most important—especially today—your product has added customer appeal when all piping is Crane. For machinery buyers know from experience that Crane Quality and "top quality" are one and the same.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas



FOR LOW PRESSURE SERVICES, *Crane recommends No. 410 100-Pound Brass Gate Valves. Upper body, cylindrical in shape, combines maximum strength with light weight; reinforces valve seats against wedging action of disc. Non-rising stem; screwed or solder-joint ends. Working pressures: 100 pounds saturated steam; 150 pounds water of 200° F.; 150 pounds oil or gas of 150° F. Sizes: ¼ to 2-inch. See your No. 49 Crane Catalog, page 15.*

FOR A BROADER SELECTION OF BETTER PIPING ...LOOK TO THE CRANE LINE



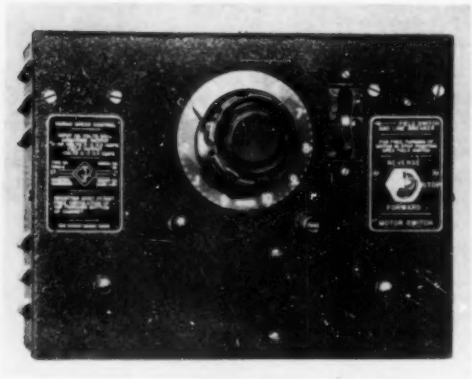
Equipped by Crane— *Duplex Service QUICK-TEMP Heating and Drainage System by Fred H. Schaub Engineering Co., Chicago*

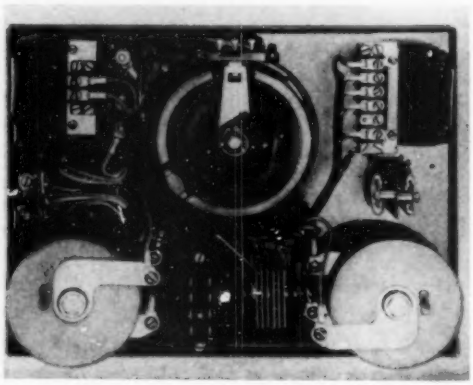
EVERYTHING FOR EVERY PIPING SYSTEM

CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING

Speed Control For One-Third Hp Motor





Being of similar design to previous models of the Variac speed control mechanism, the new model, known as Type 1700-B, has the important features of instant starting and freedom from tube replacement. For a $\frac{1}{3}$ hp motor control, these features are made possible by the use of selenium rectifiers in place of the rectifier tube used in the earlier model. Tests on these new rectifiers indicate long life expectancy for ordinary applications.

The new control has the field supply isolated from the armature circuit by a transformer. This means that standard compound-wound motors having five leads can be reversed by means of the switch on the control. Strong dynamic braking is obtained in the stop position, although the motor can be stopped without dynamic braking if the a-c input switch is used. Starting is instantaneous and the short-period overload capacity is large enough so that heavy loads can be started quickly. A time-delay magnetic circuit breaker protects the control and motor in the event of a stall.

Speed can be controlled from rated motor speed down to zero. The rpm rise in speed between full load and no load is roughly the same at all speeds and is about 400 rpm. There are no torque pulsations which will allow standard motors to be used at their full ratings.

General Radio Co., 275 Massachusetts Ave., Cambridge, Mass.

Air Friction Clutch Operates at High Speed

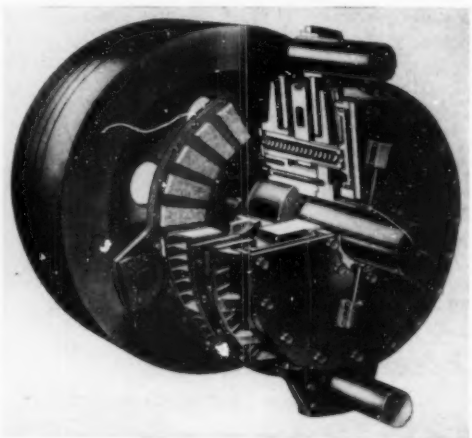
Designed for 25 hr operation at high speed, this air friction clutch is said to have the following advantages. First, it is fast acting. Positive clutch and brake engagement is achieved through a driving disk arrangement in which movement between full engagement and braking is only a fraction of an inch.

Second, it is cool running. Self-induced ventilation provides rapid heat dissipation. The friction plates are arranged to assist centrifugal blower action, directing a strong current of cooling air on the surfaces where the heat is generated. Cycle-welding of linings to plates encourages rapid heat transfer. Cycle-welded bond holds firm at temperatures well above maximum operating temperature of clutch.

Third, it is adjustment-free. Plates are arranged to compensate for wear automatically.

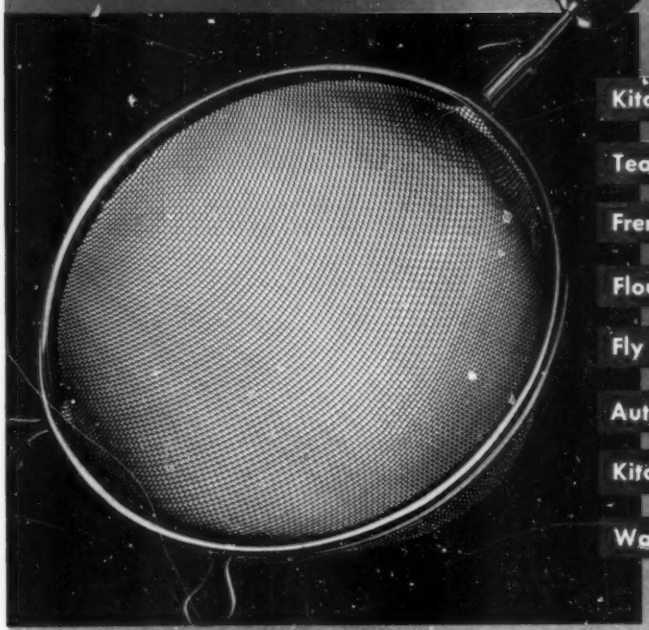
Fourth, friction linings for both clutch and brake are mounted on removable insert plates which can be replaced easily and quickly without disassembling the clutch. Clutch and brake act as a single unit, preventing overlapping engagement.

E. W. Bliss Co., Canton, Ohio



CONTINUED ON PAGE 216

WIRE CLOTH for kitchen tools



Kitchen Strainers

Tea Strainers

French Fry Baskets

Flour Sifters

Fly Swatters

Automatic Dishwasher Baskets

Kitchen Range Air Filters

Water Faucet Filters

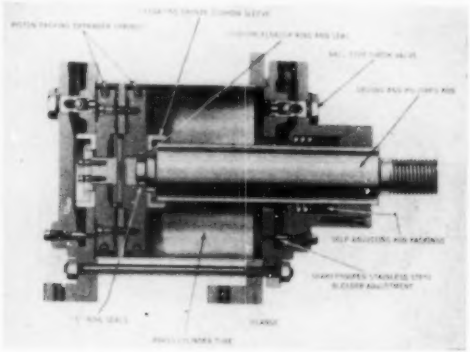
If you use wire cloth—whether it's for dishwashers or diesels... automobiles or aircraft... flour sifters or floor furnaces... french fryers or farm tractors—1-inch to 120-mesh—consult Reynolds Engineers.

REYNOLDS WIRE DIVISION
NATIONAL-STANDARD COMPANY

DIXON, ILLINOIS

NS NATIONAL-STANDARD Company

LP Cylinder Has Cushioning and Sealing Device



The design of this LP cylinder offers: a cork floater ring which facilitates cushion alignment with the head and insures a seal during cushioning; springback chevron rod packings which are self-adjusting for correct compression. The flange design which permits removal of the front head without disturbing the mounting, is another feature.

This LP cylinder is designed for operation up to 110 psi and, with modifications, for higher pressures depending on the cylinder diameter and operating medium (air, oil or water). Standard models of cylinders will cover most mounting requirements.

Hanna Engineering Wks., Chicago, Ill.

Aircraft Type Pushbuttons are Vibration Resistant

These pushbuttons are specifically designed for aircraft service in such functions as fire control, turret control, communication circuits, signal systems, and remote control of relays, solenoids and motors.

They are said to be vribration resistant at frequencies up to 55 cycles per sec, with a total extrusion of $\frac{1}{8}$ in. without contact arcing. Acceleration up to 10 G's will not cause malfunctioning in any position. Full rating of 15 amp inductive load at 30 v d-c is possible at 40,000 ft above sea level. Extreme temperature ranges from —650 to +160 F will not interfere with proper operation of the button.

Two basic types are now in production. The two point, two terminal type is available with either normally open or normally closed contacts, in a variety of flange and mounting arrangements. The three point, three terminal type is furnished with open contacts, with various mounting arrangements, and identification disks under the Lucite cap.

Square D Co., Detroit 11, Mich.

STAMP-INK, a stamping ink that was developed in the laboratories of an aircraft manufacturer, is said to be non-corrosive, and non-etching, and to have good adhesion on all metals, especially aluminum, magnesium and stainless steel. Organic Products Co., P. O. Box 456, Irving, Texas.

THERMOPLASTIC TUBING that is intended for use as "spaghetti" for electrical wiring, is said to withstand temperatures from —150 F to +375 F continuously. Known as Fluoroflex C, it is transparent, non-inflammable, and resistant to acids and alkalies. Resistoflex Corp., Belleville 9, N. J.

AN ELECTRICAL PLUG having a sliding top with brass points that pierce and connect No. 18 parallel wire, can, it is said, be connected without tools, much faster than the ordinary type of plug. Molded of Bakelite Phenolic, it is available from Gilbert Mfg. Co., 24-20 46th St., Long Island City, N. Y.

CONTINUED ON PAGE 218

On Battle Roads or Highways
ELASTIC STOP NUTS
Guarantee Tight Fastenings

Rough terrain and rough handling are hazards to the world famous military 'Jeep'. That's why Willys builds its 'Jeeps' and other vehicles with Elastic Stop Nuts at important points to eliminate fastener failures due to vibration.

In this vehicle the famous Red Locking Collar of the Elastic Stop Nut holds firm against vibration—reduces maintenance—on vital applications such as: accelerator hinge, universal joints, body hold down, spring shackles, radiator hold down, and air cleaner. The Red Collar grips bolt threads firmly—protects against vibration, impact, and stress reversal—prevents freezing of nuts to bolts by protecting internal bolt threads against corrosion.

Check the advantages of Elastic Stop Nuts against any other type of self-locking fastener. You'll find that only ESNA offers a complete line of thread sizes and varied nut types engineered to simplify your assembly line fastening problems and to provide your customers with maintenance-free operation.

Whether you are manufacturing equipment for rough military use or designing better performance and easier maintenance into equipment for your normal market . . . use vibration-proof fasteners. Now is the time to get full information. Write for complete product line bulletin to Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, N. J.

DESIGN AHEAD WITH ESNA

THE FAMOUS RED ELASTIC COLLAR IS VISIBLE EVIDENCE OF LOCKING SECURITY

Threadless and permanently elastic, it provides these 4 outstanding features:

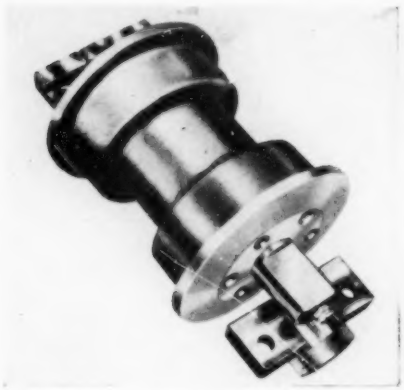
1. Protects against nuts loosening due to VIBRATION
2. Keeps locking threads CORROSION FREE
3. Provides for accurate BOLT LOADING
4. Seals against LIQUID LEAKAGE along the bolt threads

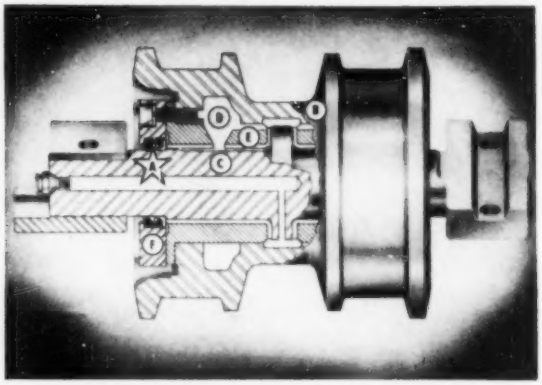
And can be used again and again

ESnail® ESNA ROLLPIN

ELASTIC STOP NUTS

DESIGN HEADQUARTERS FOR SELF-LOCKING FASTENERS





Track Roller Has Dirt Exclusion Feature

A dirt exclusion feature provided in this track-roller, depends in its operation on "flow-away" sealing, which permits a small amount of grease to pass outward through the seals, while excluding dirt or any abrasive matter from the roller. Use of mounting blocks instead of the conventional end collars provides sufficient clearance between the blocks and the seal to allow grease to escape. The one-piece roller shell is made of uniform-section manganese alloy steel casting with extra grease capacity reservoirs built into the shell. The shaft is center thrust type. Roller shell, shaft, and bearings have the same dimensions as caterpillar rollers.

Cut-away view in picture shows: (A) dirt exclusion seal; (B) one-piece shell; (C) center thrust type shaft; (D) large grease reservoirs having five times the capacity of conventional rollers; (E) bronze bushing; (F) seal housing.

Craig Carroll Co., 1707 S. E. 22nd Ave., Portland, Ore.

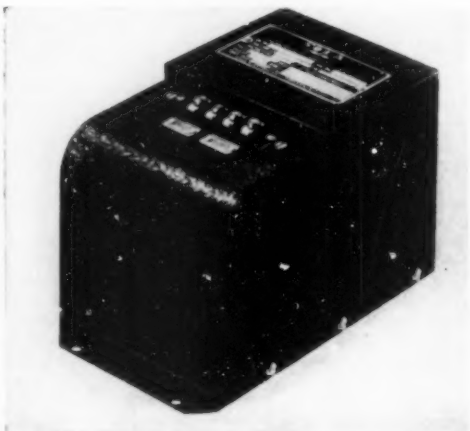
Control Device Reacts to Small Voltage Changes

A control device called the Sensivolt that controls electrical machinery by reacting to slight changes in the voltage of alternating current, has been developed for applications such as remote operation of auxiliary power equipment at isolated stations; protection of motors and other electrical equipment against excessively high or low voltage; step by step voltage regulation; and control of several selective voltage circuits from a single variable source.

The Sensivolt can be used to react automatically to fluctuations in line voltage; or it can be stimulated by modulating voltage at the power source.

The electrical circuit consists of three windings; a primary winding, a secondary winding, and a relay coil winding in series with a capacitor which comprise the resonant circuit. The magnetic circuit consists of a closed core provided with a magnetic shunt.

When low voltage a-c is applied to the primary winding of the transformer, very little of the flux generated cuts the secondary winding, due to the loose coupling. By controlling the reluctance of the magnetic circuit, the voltage of the secondary can be controlled. The point at which the secondary voltage suddenly rises with the increase in primary voltage is controlled by the constants of the resonant circuit design. The point at which the relay drops out is controlled largely by the value of the resistor.

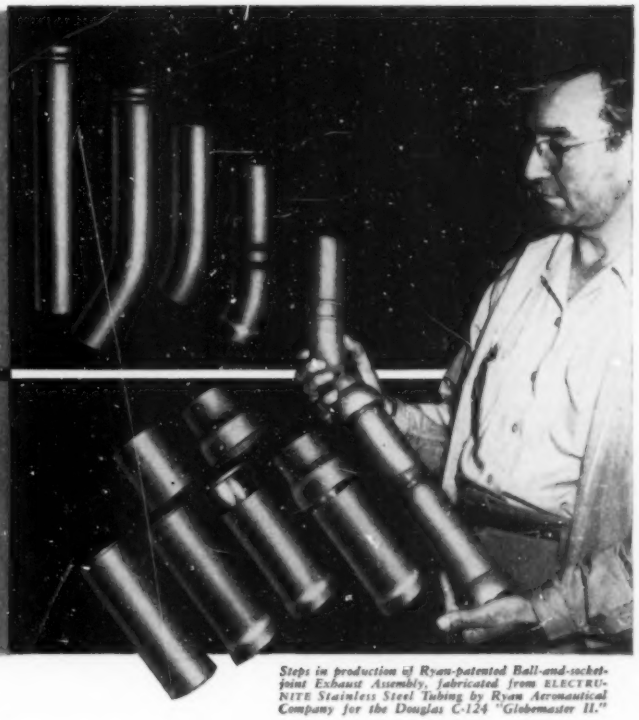


Controls can be made for any power system frequency, but it is necessary to have a fixed frequency.

Sola Electric Co., Chicago, Ill.

—CONTINUED ON PAGE 220

They're saying *Mighty Fine Things* about ELECTRUNITE TUBING at Ryan...



Steps in production of Ryan-patented Ball-and-socket-joint Exhaust Assembly, fabricated from ELECTRUNITE *Stainless Steel Tubing by Ryan Aeronautical Company for the Douglas C-124 "Globemaster II."*

"...lends itself very well to achieving unusual configurations..."

•

"...production is conducted with high degree of efficiency and low factor of waste..."

•

*"...*ELECTRUNITE'S *uniform wall thickness allows sure, safe, controllable bending of the tube without wrinkling..."*

•

"...uniform in diameter, strength, weight, workability and other characteristics..."

Expanded on a punch press, swaged, bent to shape . . . then subjected to hundreds of service hours at cherry-red exhaust temperatures and under severe vibration . . . that's the punishment dealt out to these stainless steel exhaust stacks on the Douglas C-124 "Globemaster II."

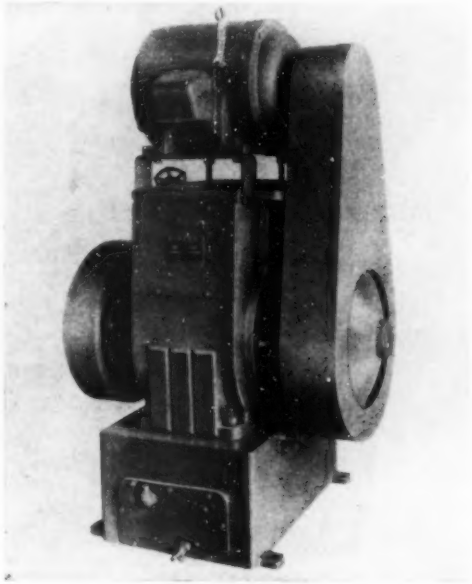
High physical and metallurgical accuracy are two of many advantages Ryan gained by specifying Republic ELECTRUNITE Tubing. Ryan metallurgists were assisted in their choice of the right ENDURO stainless steel alloy by Republic's 3-Dimension Metallurgical Service . . . a combination of field, laboratory, and mill metallurgical advice.

You can have the benefits of Republic's 3-Dimension Metallurgical Service for your products . . . a letter or phone call will bring the Republic Field Metallurgist to you.

REPUBLIC STEEL CORPORATION
STEEL & TUBES DIVISION
224 EAST 131st STREET • CLEVELAND 8, OHIO

Republic
REPUBLIC STEEL
ELECTRUNITE
STAINLESS STEEL TUBING AND PIPE

Water-cooled Vacuum Pump Is Self Contained



This self-contained pump, Model 812-F, has a capacity of 500 cfm and is said to be suitable for any type of vacuum processing work. It is a water-cooled unit which operates at 390 rpm with a top-mounted 25 hp motor; net weight is 2,400 lb, height is 76 in., and it occupies a 36 by 38 in. floor space. Called the Microvac pump, it is the largest to be made by this manufacturer.

It operates at a high volumetric efficiency due to the complete discharge of air at each stroke, with no chance for re-expansion. With only four moving parts and low relative surface motion of piston to housing, minimum wear and low up-keep can be expected. These high-vacuum pumps discharge slugs of liquid without injury to the pump. The oil reservoir is located in the pump base, where lubricating oil settles when pump is shut down and vacuum is broken; there is no danger of flooding the pump cylinder. Oil flows automatically to all parts when the pump is started again.

Processes where this pump may be applied are drying and freeze-drying equipment, impregnators and dryer-impregnators, distilling, extraction and solvent recovery apparatus, and fumigation units. Complete data on the 812 F Microvac pump is available from the manufacturer.

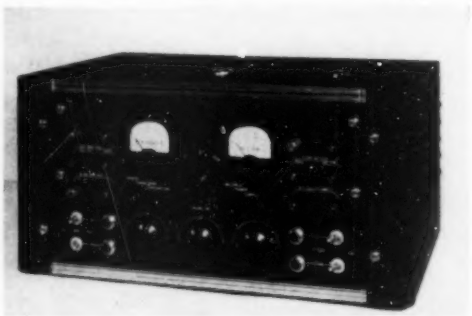
F. J. Stokes Machine Co., Philadelphia 20, Pa.

Multiple Power Supply Provides Range of Voltages

A single compact unit that provides virtually all of the low voltages required in the normal experimental laboratory setup features two regulated d-c supplies completely independent and isolated from ground and each other. They may be used singly or in any combination with either the positive or negative terminal grounded. In addition, a filament supply, a negative 150 v bias supply and a nominal 28 v d-c supply suitable for relay, small motor or similar applications are included in the unit.

The regulation of channel A is held to better than 1 percent for rated load current and for line variations between 105-125 v over the output range of 30-300 v. Channel B maintains this regulation over its full range of output voltage. Both supplies feature low output impedance with ripple voltage held to less than five millivolts.

Features are: separate power switches for each channel; complete fusing for all voltages; voltmeter and ammeter switching to monitor all regulated voltages; and, a fused outlet for operating external equipment.



The complete unit called the model 610 is housed in a cabinet 10½ in. high by 22 in. wide by 15 in. deep or can be supplied without cabinet for relay rack mounting.

Bristol Engineering Corp., Lincoln Ave. & Pond St., Bristol, Pa.

PRINTED PRESSURE-SENSITIVE TAPE, which requires no wetting or use of adhesives, can be furnished in flat individual pieces, in almost any size, in any number of colors, square or die-cut, and in any quantities above the five thousand minimum order. A multi-purpose tape, each piece is furnished with a protective backing covering the adhesive side, and which is stripped off at application time. Topflight Tape Co., York, Pa.

A SHUT-OFF OR DIRECTIONAL FLOW VALVE that has a stainless steel plug precision lapped into a forged aluminum body can be used for air, water, alcohol, gasoline, or oil. Kohler Precision Products Co., Dayton, Ohio.

CONTINUED ON PAGE 222

Shape of things to come...

From Your Blueprint . . . to Your Product

OSTUCO TUBING

Tapering • Swaging • Flanging • Bending
Upsetting • Expanding • Reducing • Beading
End closing • Spinning • Drilling • Slotting
Notching • Flattening • Shaping • Trimming
Threading • Angle Cutting • And Many Others

Products for the future take shape on the drawing boards of today. And scores of manufacturers are planning ahead for the time when emphasis will again be on production of consumer goods.

In shaping your products to meet tomorrow's demands, consider OSTUCO Steel Tubing. It offers so many outstanding advantages . . . so many unusual opportunities for design improvements, increasing strength while reducing weight, enhancing beauty, and lowering production costs.

Because of the continuing needs of the military services, we cannot always promise early delivery estimates on new civilian orders. However, our experienced tubing engineers are at your service now to help give your product a future with OSTUCO Steel Tubing.

THE OHIO SEAMLESS TUBE COMPANY

Manufacturers and Fabricators of Seamless and Electric Welded Steel Tubing
Plant and General Offices: SHELBY 7, OHIO

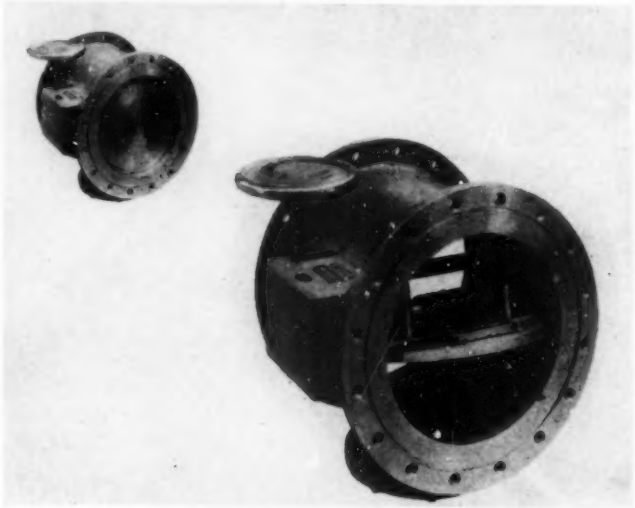
SALES OFFICES: BIRMINGHAM, P. O. Box 2021 • CHICAGO, Civic Opera Bldg., 20 N. Wacker Dr. • CLEVELAND, 1328 Citizens Bldg. • DAYTON, 511 Salem Ave. • DETROIT, 520 W. Eight Mile Road, Ferndale • HOUSTON, 6833 Avenue W, Central Park • LOS ANGELES, Suite 300-170 So. Beverly Drive, Beverly Hills • MOLINE, 617 15th St. • NEW YORK, 70 East 45th St. • PHILADELPHIA, 1613 Packard Bldg., 15th & Chestnut • PITTSBURGH, 1206 Pinewood Drive • ST. LOUIS, 1230 North Main St. • SEATTLE, 3104 Smith Tower • SYRACUSE, 501 Roberts Ave. • TULSA, 733 Kennedy Bldg. • WICHITA, 622 E. Third St. • **CANADIAN REPRESENTATIVE:** RAILWAY & POWER CORP., LTD.

Large High Vacuum Valve Operates Easily, Quickly

This 16 in. high vacuum valve is a hand wheel operated butterfly type designed to augment the existing line of smaller valves described in the January issue of PRODUCT ENGINEERING page 182. The hand wheel is connected to a worm gear drive which enables the operator to spin the handwheel after it is started. Ten turns of the wheel are necessary to open and close the valve. The worm wheel action automatically locks the valve when it is opened under vacuum.

This valve is designed for pressure differential in both directions. Positive seal is said to be obtained through cam actuation of the valve disk. A full scale indicator shows the extent to which the valve is opened or closed. The valve is available in special metals for corrosive applications where standard metals are not sufficiently resistant to corrosive vapors.

F. J. Stokes Machine Co., Philadelphia 20, Pa.



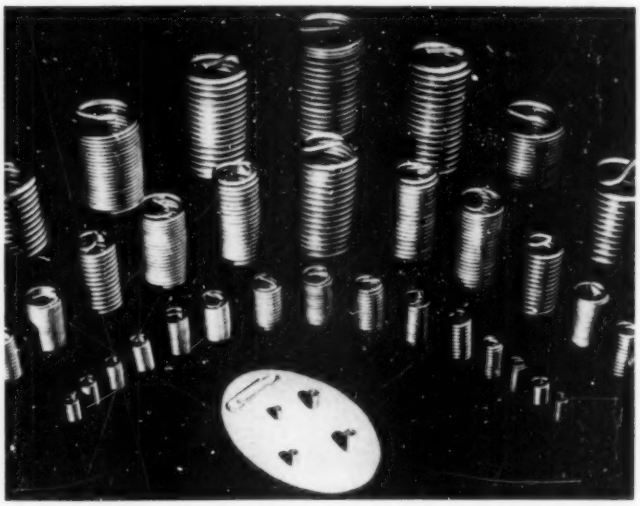
Heli-Coil Thread Inserts for Small Holes

Four new small-size stainless steel helical-wire thread inserts, for strengthening tapped threads in aluminum, magnesium, plastic, iron, steel, brass, bronze and wooden components, are available in 8-36 and 6-40 sizes in the fine-thread series, 5-40 and 4-40 sizes in the coarse-thread series and are available in 1, 1½ and 2 dia lengths.

Standardization of these new insert sizes was stimulated by the needs of household-appliance and business-machine manufacturers for small-size anti-stripping, anti-abrasive and anti-corrosive threads in the housing of sewing machines, vacuum cleaners, adding machines, and typewriters.

Helical-wire thread inserts have three industrial applications. They are used as original manufacturing components in new equipment. They are also used in production salvage operations, to repair threads damaged during manufacture and in maintenance operations, to repair threads damaged during prolonged use.

In addition to the new small-size inserts, the following sizes and types are available: 6-32 to 1½-6 sizes of National Coarse and National Fine thread inserts, 10 mm to ⅞-18 of automotive spark plug inserts, and ⅛-27 to 1-11½ of pipe thread inserts.



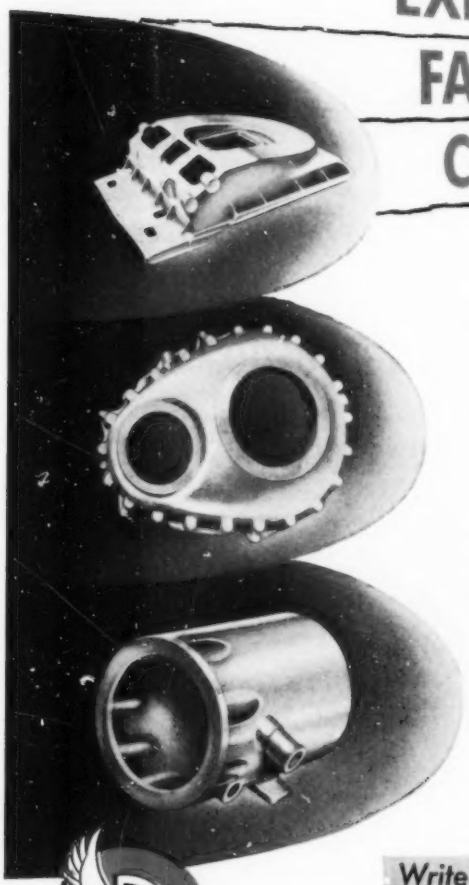
Heli-Coil Corp., 47-23 35th St., Long Island City 1, N. Y.

CONTINUED ON PAGE 224

FOR YOUR DEFENSE JOBS . . .

your Aluminum Castings supplier must have

EXPERIENCE
FACILITIES
CAPACITY



These three essentials to reliable service protect you when you select Aluminum Industries, Inc., as your supplier of aluminum castings.

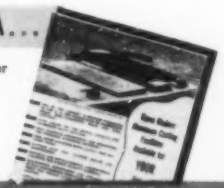
EXPERIENCE — Over 30 years of experience in working with aluminum and its alloys are behind the skill and "know how" of our metallurgists, engineers and foundry personnel.

FACILITIES — In each and every department, from the physical and metallurgical laboratories clear through to the finishing department, the most modern equipment is employed for precision processing, and to control quality at every step of production.

CAPACITY — You'll avoid delivery worries, too. With one of the largest aluminum foundries in the United States for the production of Permanent Mold, Semi-Permanent Mold and Sand Castings (monthly capacity over 2,500,000 lbs. of castings), you can depend upon Aluminum Industries to deliver your aluminum castings when you need them.

Write for Bulletin 20-A...

This new Bulletin illustrates and describes our complete facilities for serving your aluminum castings requirements. Recommendations and estimates given without obligation.



PERMITE

ALUMINUM INDUSTRIES, INC.

CINCINNATI 25, OHIO

DETROIT, 809 New Center Building · NEW YORK, 9 Rockefeller Plaza · CHICAGO, 24 E. Jackson Boulevard · ATLANTA, 823 Grant Building

ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS... HARDENED, GROUND and FORGED STEEL PARTS

Capacitor Motors Have Resilient-Base Construction

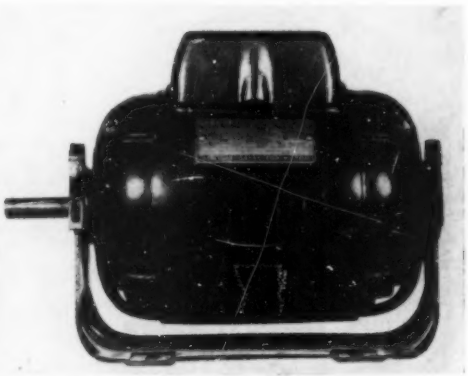
For use where freedom from vibration and extra quiet operation are required, these single-phase, capacitor induction motors with a resilient-base construction are available in ½ to 5 hp ratings.

According to reports, all single-phase motors have some torque pulsation, but the resilient base isolates this vibration so that it is not transmitted to the driven machine.

Dynamically balanced for smooth operation, these motors offer protection against physical damage, electrical breakdown, and operating wear and tear. Of cast iron construction, it features a totally-enclosed built-in transfer switch to keep foreign matter from the contacts, and a centrifugal mechanism designed for long life. The motor is equipped with long-life lubricated ball bearings and readily accessible grease fittings.

Except for the 5 hp size, which uses 230 v only, the motors operate on 115/230 v, 60 cycle power supply. Automatic-reset thermal protective devices are available.

General Electric Co., Schenectady 5, N. Y.



Electric Micrometer Has Tolerance of 0.00002 Inches

Rapid and accurate measurements to a tolerance of 0.00002 in. are claimed for this new electronic micrometer. An electronic circuit used in conjunction with an accurate micrometer head permits pressureless measurement and eliminates feel as a source of error. The electronic circuit is sufficiently sensitive to give a positive on and off indication with only five millionths of an inch displacement at the contact. Models are available with different work capacities for measurement on compressible or non-compressible materials. All models are portable, require no levelling and are unaffected by vibrations, variations in temperature, line voltage or aging of electronic tubes.

The electric micrometer can be used for measurement of machined parts, ball bearings, small assemblies, depths of counterbore. It can be used to measure deflection in diaphragm, bi-metal elements, springs, bellows and similar applications requiring measurement without pressure. It can be applied to paper, foil, ribbon, rubber, felt, plastic sheets, linoleum, photographic film and textiles.

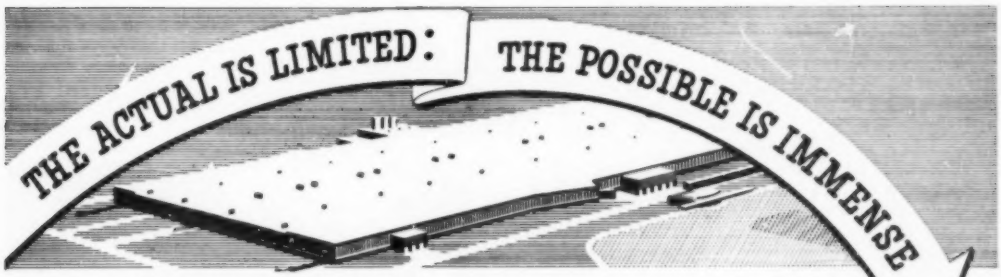
J. W. Dice Co., Englewood, N. J.

A NEW ADHESIVE, Ardux 120, for rubber-to-metal bonding makes it possible to brush coat the metal and rubber surfaces, with the mixture, apply a pressure of about 10-20 psi for 15-20 min at 110-120 C or for 5 min at 140-150 C and achieve a firm durable bond. In contrast to other processes, bonding methods are no different for aluminum, magnesium, steel, etc., than for bonding rubber to any other copper-bearing ferrous or non-ferrous metal. Plastics Div., Ciba Co. Inc., 627 Greenwich St., New York 14, N. Y.

A NEW CLASS OF CLEANING COMPOSITIONS, remove solid soils by detergent action and continue to clean effectively even when loaded with soil. The range of solvent power inherent in the new solubilizing cleaners makes them very effective when used for removing such complex soils as buffing compounds, heavy greases and pigmented drawing compounds. Pennsylvania Salt Mfg. Co., 1000 Widener Bldg., Philadelphia 7, Pa.

A TEMPERATURE INDICATING LIQUID to indicate 2,000 F is known as Tempilag. This fluid can now be obtained in 12 or 13 deg steps from 113 to 400 F and in 50 deg steps from 400 to 2,000 F. Tempil Corp., 132 W. 22nd St., New York 11, N. Y.

CONTINUED ON PAGE 226



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

© LE Co. 1951

HOW ECONOMIES OF WELDED STEEL CUT YOUR PRODUCTION COSTS

WHEN designs utilize the economies of welded steel construction, invariably costs are less. That's because fewer pounds of less costly material are needed . . . Each pound of metal can be more easily concentrated where it does the most good.

Wherever costs are higher, inevitably the designs have fallen short of embodying the potential savings, or the products themselves have been overdesigned. A careful reappraisal by the shop before a design is "frozen" simplifies construction details and eliminates every unnecessary expense for lowest cost of manufacture.

Your Lincoln Welding Engineer will gladly help you analyze your designs and point out various cost reduction possibilities. Simply call or write.

Fig. 3. Saves 51% Cost *by forming lever arm and pad as integral piece from 10 gauge metal. Weighs 2.5 pounds . . costs 54¢.*

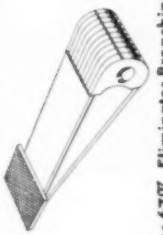


Fig. 4. Saves 67%. Eliminates Broaching. *Hub with integral key is produced by stacking stampings in assembly. Arm is 10 gauge, brake formed and welded to hub. Cost is only 31¢ . . . weight 2.2 pounds.*

the ACTUAL

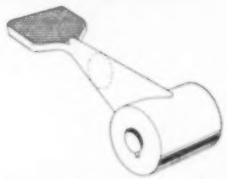


Fig. 1. Traditional Construction. *Machine foot-lever, 10 inches long, weighs 6 pounds. Cost with broached keyway is $1.15.*

increasing the YIELD

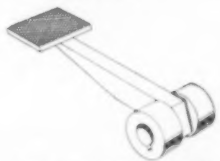


Fig. 2. Simple Steel Design Costs 34% Less. *Can be built by the shop with only saw and shears. Weighs 2.7 pounds . . . costs 68¢ complete with keyway.*

the IMMENSITY of the POSSIBLE

Unlimited opportunities to create efficient, lower cost designs.

SEE HOW STEEL BUILDS IT WITH LESS MATERIAL

Machine Design Sheets are available to designers and engineers. Simply write on your letterhead to Dept. 38,

THE LINCOLN ELECTRIC COMPANY

CLEVELAND 1, OHIO

Plastic Magnifier for Reading Parts Lists

A rectangular reading instrument of H shaped cross-section, made of a transparent plastic material either extruded or molded in various lengths to suit the different applications is useful in interpreting directional lines and dimensions on blue prints, departmental lists, and also for inspection of articles over a long section. The 12 in. length is a handy size because engineers and draftsmen can use it for part lists, where part or assembly numbers are spread across a wide page, thus allowing the reader to follow the cross-hairs across adjacent columns of tabulated material to catch the information along the line of sight.

A novel feature of the 2 X Magna-Vue, under which trade name the instrument is being marketed, is that because of its H-shaped cross-section, it is (a) pre-focused to double magnification, (b) non-scratchable and non shatterable, as the reading lens area never touches a foreign body. The device is being produced in three sizes, and may be obtained up to five feet in length.

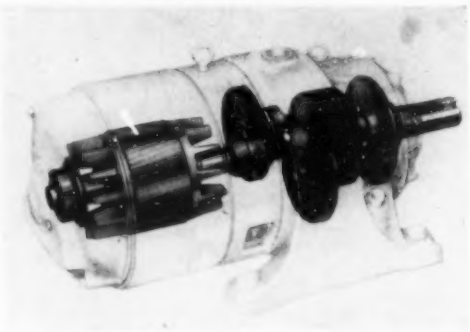
The Alston Corp., P.O. Box 146, Hollydale, Calif.

Twin Pinion Motor Develops High Torque

A geared motor designed as Type GL Syncrogear, utilizes two secondary pinions to drive one output gear. The result is said to be double the effective torque rating of a conventional single pinion and gear unit. A splined herringbone pinion is used in this reducer to equally divide the load between the two secondary pinions to obtain high torque at low speeds. A secondary advantage is the small space required, as compared to the space required of a conventional drive.

Available with rating of 5 to 25 hp and with speeds from 30 to 84 rpm, the Type GL has asbestos-protected windings, normalized castings, solid centricast rotors and Lubriflush lubrication.

For more detailed information write to the manufacturer.



U. S. Electrical Motors, Inc., 200 E. Slauson Ave., Los Angeles 54, Calif.

Glass Panel Provides Radiant Heat

To meet requirements for uniform electrical heat in production processes, a glass radiant-heating panel called the Ra-Grid Heater Plate has been devised.

An aluminum grid about one-thousandth of an inch in thickness is fused to the back of a quarter-inch tempered glass panel. Heat resisting enamel protects the grid from atmospheric corrosion and abrasion in handling. The plate is equipped with two clamp-type terminals for connection of wires.

The Ra-Grid's specifications are as follows: Maximum operating temperature, 300 F; Temperature control, thermostatic switch or by means of a basic design, so that wattage input matches radiation conditions; Voltage, 115 and 230 v types; Wattage, 3 w per sq in. with plate in free air at room temperature; Sizes, minimum: 6 by 14, or equivalent area, maximum: 16 by 28 in., and special sizes can be made to order. There are optional types of glass: Luminex, almost transparent, indeterminate pattern; Diffusex, small, slightly raised pattern, which is less transparent.

Where areas to be heated are larger than the maximum size panels, two units of the same specification may be connected in series and operated on the total voltage requirements.

Blue Ridge Glass Corp., Kingsport, Tenn.

CONTINUED ON PAGE 228

Best stop on the road

As many a bus and truck maintenance man will tell you, the best stop on the road is the stop you get with brake blocks made by RAYBESTOS-MANHATTAN. Throughout the automotive industry, in fact, manufacturers and operators agree on the advantages of R/M STOP-AND-GO products . . . brake linings, brake blocks, clutch facings, and engineered automatic transmission parts. That's one big reason why R/M has become the world's largest maker of friction materials.

In many other industries, too, R/M has won outstanding leadership in performance. You'll find R/M friction materials in applications varying from the brake blocks on a drilling rig to the clutch mechanism in a 3-wheeled scooter!

Whatever *your* friction material requirements, call in your R/M representative. He can work from samples, from designs on paper, or from figures on horsepower development combined with desired performance characteristics. Behind him stand the full facilities of four plants, four research organizations, and four testing laboratories.

RM
FIRST IN FRICTION

RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION • 620 Fisher Bldg., Detroit 2, Mich.

Chicago 11, Ill. Los Angeles 11, Calif. Cleveland 14, Ohio

Factories:

BRIDGEPORT, CONN., MANHEIM, PA., PASSAIC, N.J., NO. CHARLESTON, S.C.

CANADIAN RAYBESTOS CO. LTD., PETERBORO, ONT.

RM

RAYBESTOS-MANHATTAN, INC., Manufacturers of Brake Linings • Brake Blocks • Clutch Facings • Fan Belts • Radiator Hose • Mechanical Rubber Products • Rubber Covered Equipment • Packings • Asbestos Textiles Powdered Metal Products • Abrasive and Diamond Wheels • Bowling Balls

Check Valve Seals at Low Pressure

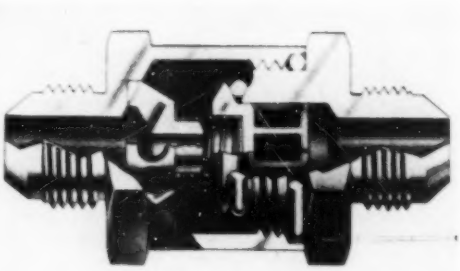
Two check valves designated as 800 series and 8,800 incorporate the basic advantages of a poppet design with the operating characteristics of a swing check valve.

Extremely low cracking pressure and pressure drop are said to have been achieved without sacrificing the characteristic dead tight sealing. The valves are suitable for engine oil, hydraulic fluid, air, carbon dioxide, helium, nitrogen and other gases, as well as fuel or fuel vapor.

Both new valves incorporate the "Circle Seal" principle which provides the following advantages: (1) Will not leak, even at very low back pressures or while handling fuel or fuel vapor; (2) Can be mounted in any position; (3) Utilizes standard "O" rings, does not require special molded parts; (4) Characteristic swell of synthetic rubber parts in aircraft or jet fuels does not adversely affect sealing action; and (5) Not affected by vibration.

The 800 Series is designed to be physically and functionally interchangeable with aircraft type swing check valves. The 8,800 Series, while functionally the same as the 800 Series, is somewhat shorter. It is intended for applications where weight-saving or compactness is of greater importance than interchangeability with swing check valves.

James-Pond-Clark, 1247 E. Green St., Pasadena 1, Calif.



Technical Characteristics of Check Valves

Operating Pressure	0 to 500 psi
Cracking Pressure	6 to 8 in. H_2O
Operating Temperature	—65 to 280 F*
Leakage	Zero

* Depending on "O" ring used.

Part Winding Starter Eliminates Current Surges

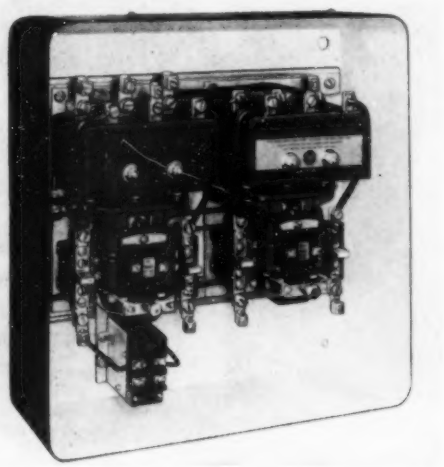
This a-c part winding starter may be used with motors which employ two separate parallel windings, star or delta, to obtain increment starting.

The starter consists of two across-the-line starters and pneumatic timing mechanism mounted below one starter and operated by the starter's solenoid plunger.

Pressing the "start" button closes the first starter which energizes one of the two parallel windings. Meanwhile, the timer is in operation and a few seconds later energizes the second starter. With both starters closed, full line current is supplied to the motor through both windings.

Use of part winding starting does not produce current surges obtained with autotransformer starting as the motor is not disconnected from the line during the starting period. When using reduced voltage and needing two increment starting, a part winding motor may be used with this starter.

Allen-Bradley Co., Milwaukee 4, Wis.



TWO NEW COMPOUNDS Unichrome Dip Compounds 1060 and 1070, have been developed for decorative and protective finishing of zinc. Corrosion-resisting, chromate-type conversion coatings either black or olive drab in color are obtained by a simple dipping process which can be carried out at room temperature. United Chromium, Inc., 100 E. 42nd St., N. Y. 17, N. Y.

MAGNETIC PROBE READS the magnitude and direction of flux density in an air gap as small as 0.025 in. thick and 0.01 sq in. of cross section. The flux value is obtained as a steady reading on a d-c meter as long as the probe is held in the magnetic field. No jerk or pull or ballistic reading or circuit breaking is required. Dyna Labs, Inc., 132 Lafayette St., N. Y. 13, N. Y.

CONTINUED ON PAGE 230

DIE CASTINGS

BY

Stewart

41 YEARS OF SERVICE TO INDUSTRY

MACHINING AND FINISHING

Dimensional precision, beyond normal die casting tolerances, may create the need for subsequent finishing operations, the scope of which is usually determined by selecting the most economical method. Stewart's machining and finishing facilities permit you to tie your cost factors together—can be relied upon for the most exacting requirements.

Services available to you at Stewart's

- Designing
- Engineering
- Die Making
- Metallurgical Control
- Most modern Die Casting Equipment
- Complete machining, polishing and assembly facilities

We invite inquiries concerning all Die Casting problems.

STEWART DIE CASTING
Division of Stewart-Warner Corporation
4543 Fullerton Avenue, Chicago 39, Illinois
275 Warren Street, Bridgeport, Connecticut

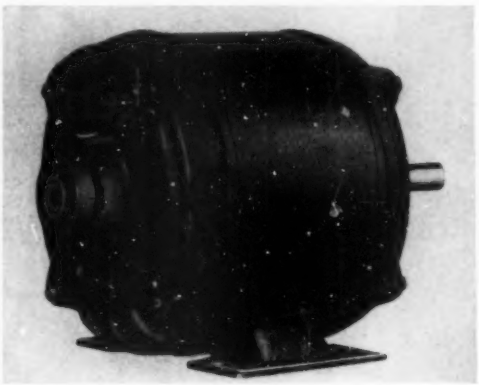
We take pride in being known by the customers we keep

Fractional Hp Motor Has High Starting Torque

This split phase fractional hp motor has a high starting torque for use where high starting current is not objectionable. Breakdown torque is in accordance with NEMA standard for the basis rating. Service factor is 1.00.

The features of this motor include: cast-iron end brackets of drip-proof design; welded steel frame; feet welded to frame, and held to accurate shaft height dimension; phosphor bronze sleeve bearing with thrust collar; wool yarn lubrication with reserve oil capacity. Shaft is precision ground, rotor is high pressure cast aluminum and each is dynamically balanced.

Polyvinol Acetal insulated wire plus Phenol Formaldehyde baked varnish are used. Rotor lamination iron is skewed for quiet operation. These motors can be furnished with a cushion base, if required. This motor, called the "Special Service" motor, incorporates features of other motors produced by this company.



Century Electric Co., 1806 Pine St., St. Louis, Mo.

Edge Lighting Material Is Non-Crazing

Instrument panels made of Sierracin 5005 edge lighting panel materials have black backgrounds with white markings for daylight visibility. At night the letters light red by means of small red lights placed in the panel. The light is carried throughout the transparent inner core of the panel and is permitted to escape only thru the translucent letters and markings. Lights may be properly located in the panel for even lighting, and light bulbs are replaceable from the front of the panel. The screw-in light sockets may be used to hold the edge lighted panel on the instrument board.

A thermosetting plastic, Sierracin is said to not craze in the presence of alcohol, Lacquer thinner, Methyl Ethyl Keytone, standard commercial cleaners, aviation gasoline or skydrol. The panels are integrally molded into one sheet eliminating possibility of delamination.

Panel markings are produced by engraving through the black and white surfaces and slightly into the transparent center core. The letters are then spray filled with a translucent white plastic, alowed to cure and the entire panel is washed with lacquer thinner. This method is said to afford long effective light transmission, even lighting intensity and reduces parallax to a minimum. Panels can be lighted satisfactorily at a distance of 5 in. from the light source. The engraved letters are reported to be free from distortion.

The black surface of the panels provides a durable and dull non-reflecting surface and produces good contrast with the white markings for daylight visibility. The surface is said to withstand scratches from a phonograph needle bearing more than a 1,000 gram load.

Edges are coated with air drying catalysts to permit fast drying and an opaque white is used for added protection against light leaks at edges, corners and hole rims.

To machine Sierracin plastic, helical tooth cutters or routing tools should be used for best results. It cuts cleanly when engraved and sawing can be done with hollow ground circle saws with no set on the teeth. Holes should be drilled by grinding the drills to long tapering points or to a flat end similar to drills used for rubber where the cutting edge or lip of the drill flute protrudes. Coarse grinding wheels should be used.

Sierracin 5005 panels may be formed by heating to 240 F for 30 min and forming over rubber covered blocks of wood or plaster. The panels should be held in place and allowed to cool to room temperature.

The physical and chemical properties are as follows:

Tensile strength	9,000 psi
Compressive strength	30,000 psi
Flexural strength at −70F	15,000 psi
Heat distortion point	170 F
Elongation	4 to 6 percent
Thermal conductivity	4.5–5
Thermal expansion	5.5 to 7 percent per deg F
Light transmission	90 percent

Sierro Products Co., Compton, Calif.

POMDERFILM, a rust and corrosion prevention coating, can be brushed, sprayed or wiped on metal surfaces or on painted or plated parts. It dries to form a non-oily protective film that will not crack or chip or collect dust. The Thomas Co., Chemical and Coatings Div., 1645 Hennepin Ave., Minneapolis 3, Minn.

CONTINUED ON PAGE 232

NEW CATALOGS AND BULLETINS

A Reader Service To Help Keep You Up-to-Date

(1) BATTERY CHARGING EQUIPMENT—The Electric Products Co. Bulletin 11-210, 4 pp. Illustrations and descriptions of portable motor generator battery charging units designed for inexperienced men to operate. Fully automatic. Specifications for various type batteries given.

(2) SHEET PACKINGS—Raybestos-Manhattan, Inc. Bulletin, 8 pp. Gives descriptions and illustrations of each type packing, with service recommendations, standard sheet sizes, weights and thicknesses in which sheet is available.

(3) ELECTRONIC INSULATION MATERIAL—Metal Textile Corp. Bulletin, 8 pp. Illustrations and descriptions of problems of shielding, sealing, and conductivity in electronic equipment, and kind of material used.

(4) SECONDARY TRANSFORMER CONTROL—Heinemann Electric Co. Bulletin 2015, 4 pp. Illustrations, descriptions and diagrams showing advantages of secondary banking of distribution transformers over solid banking, and cut-away view of control device.

(5) SEAMLESS TUBING—Tube Reducing Corp. Bulletin R5, 8 pp. Illustrates and describes the method for producing precision, compression formed tubing, and how sizing is accomplished using various metals and bi-metal combinations. Also discusses straight and tapered tubes, and forming of tubes.

(6) CONTROL SYSTEM—Taylor Instrument Co. Bulletin 98097, 24 pp. Descriptions and color illustrations of the main features of this control system. This book is divided up into sections covering the controller, the transmitters, and the recording and indicating receivers.

(7) LAMINATED PRODUCTS—Keller Products Inc. Bulletin, 10 pp. Complete with illustrations, it describes the various types of laminated products produced in the three categories of flat and molded curved plywood; laminations combining metal, wood, plastic and cloth; reinforced plastics.

(8) TACHOMETER—Metron Instrument Co. Bulletin 42 R, 2 pp. Illustrations and descriptions of applications, installation, servicing of tachometer having ability to measure speeds of up to 10 machines.

(9) INSULATED TERMINALS—The Thomas & Betts Co., Inc. Data Sheet S4, 2 pp. Complete information on new line of self-insulated terminals with applications for electronic equipment, instruments, industrial controls, aircraft, railway, and marine service.

(10) AIRCRAFT FITTINGS—Resistoflex Corp. Bulletin, 12 pp. Information on hose assemblies for aircraft. Also details on new short radius, full flow forged aluminum elbow fittings, and test data.

(11) CONSTANT DELIVERY PUMPS—The Oilgear Co. Bulletin 46601, 4 pp. Illustrations, descriptions, and specifications for three constant delivery axial piston pumps for pressures up to 3,000 and 5,000 psi. Pumps have balanced flat valves, rolling pistons, and reverse flow high pressure and supercharging pressure relief valves.

(12) Stainless Steels—Republic Steel Corp. Booklet, 12 pp. Illustrated booklet describes the type 430 stainless steel (containing no nickel) in comparison with types 302 and 304 (restricted due to nickel content). Data given concerning performance under corrosive conditions, and mechanical properties.

(13) BALL BEARING SWIVEL JOINTS—Chiksan Co. Catalog, 50-D, 20 pp. Colored illustrations, with descriptions and specifications on swivel joints and fabricated products for petroleum and chemical industry.

(14) PRECISION SWITCHES—Micro Switch Co. Bulletin 54, 4 pp. Condensed illustrated circular divided into sections, dealing with special group of switches. Covers heavy duty limit; medium duty limit, explosion proof, high capacity enclosed, die cast enclosed, actuators.

(15) FLUSH LATCHES AND HINGES—Hartwell Co. Catalog, 24 pp. Colored illustrations showing various types of latches and hinges, where used, and method of installation.

(16) PRECISION SPEED CONTROL—Electric Machinery Mfg. Co. Booklet 1107, 32 pp. Contains illustrations, charts and diagrams, and information on magnetic drive and magnetic amplifier speed control and how used in industry.

(17) SMALL PARTS WELDING—Federal Tool Engineering Co. Bulletin 252, 8 pp. Information on new bench head line for small parts welding. Single pair electrodes, double pair electrodes, two welds simultaneously.

(18) SOCKET SET SCREWS—Standard Pressed Steel Co. Booklet. Description of Unbrako Standards. Information on socket head cap screws; self locking socket set screws; shoulder screws or stripper bolts; pressure plugs, and socket screw keys.

(19) ULTRAVIOLET RATING—Menlo Research Lab. Booklet. Describes use of Fluoretor as fluorescence detector; can be operated without regard to daylight or outside light conditions.

(20) ANHYDRIDES—Carbide & Carbon Chemicals Co. Booklet F-5280A, 16 pp. Describes all anhydrides used by the company, uses, physical properties, and shipping data. Also covers specifications and description of test methods used.

(21) HYDRAULIC PRESSES—Sepore Corp. Bulletin, 4 pp. Illustrations of the various types of presses produced with capacities up to 150 tons. Also views of production in foundry.

(22) SPROCKETS—E. B. Sewall Mfg. Co. Catalog No. 51, 68 pp. Illustrations and

HOW TO ORDER—To request more information on any advertised item, jot down the page number of the ad and the initials of the advertiser. For new bulletins, circle the numbers.

PRODUCT ENGINEERING Not good after 11/1/51

Please send complete information about the products advertised on the following pages:
(Use initial of company if more than one advertisement appears on the page)

....

....

....

Send copies of the new bulletins and catalogs circled below to my attention.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49

Name..... Title .....

Company.....

Address..... 9/51

Postage Will be Paid by McGraw-Hill Pub. Co.

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD

First Class Permit No. 64, (Sec. 34.9, P. L. & R.) New York, N. Y.

Reader Service Manager
PRODUCT ENGINEERING
330 West 42nd Street
New York 18, N. Y.

information on a series of sprockets designed for standard roller chains. Included are plate sprockets without hubs, with cast iron hubs, one and two side hub projections.

(23) ELECTRONIC TEMPERATURE CONTROL—Vapor Heating Corp. Bulletin No. 518, 45 pp. Color illustration, cross-sectional views and description of the electronic thermostats and temperature control. Gives typical schematic circuit diagrams together wth specifications for various installations.

(24) DIE CASTING—Char-Lynn Co. Bulletin, 16 pp. Illustrations and description of die casting procedures, finishing operations, die making, and hydraulic equipment.

(25) DIAPHRAGM VALVE—Hills-McCanna Co. Catalog V-50, 36 pp. Contains colored illustrations, description of operation, and cutaway views of handwheel operated, quick opening, sliding stem, and air operated all purpose diaphragm valves. Also gives complete specifications and service recommendations.

(26) RETAINING RINGS—The National Lock Washer Co. Catalog RR-50, 12 pp. Information on various types of retaining rings produced, various materials and finishes available. Has table of specifications for sizes of rings and illustrations of how assembled.

(27) TRANSDUCERS—Statham Laboratories, Inc. Catalog, 64 pp. Illustrations and descriptions of various types of transducers. Explanation of operation, specification tables, operation curves, circuit diagrams, and mathematical formulae included.

(28) AIRCRAFT TRANSFORMERS—General Electric Co. Bulletin GEA-4866A, 28 pp. Information and circuit diagrams for ballast for aircraft fluorescent lighting, flyweight silicone transformers, jet ignition transformers, and general purpose transformers. Illustrations and table of specifications.

(29) LIQUID LEVEL GAGES—Meriam Instrument Co. Booklet C-12, 44 pp. Illustrates and describes types of manometers, inclinometers, draft gages, liquid level gages and sight feed bubblers.

(30) MAGNETIC RELAYS—North Electric Mfg. Co. Bulletin, IR511, 88 pp. Illustrations, operational characteristics, and general application of the various types of relays constructed. Also constructional diagrams.

(31) PRECIPITATION HARDENING STAINLESS—Armco Steel Corp. Booklet, 16 pp. Properties, available forms and fabrication of Armco 17-4PH and 17-7PH stainless steels are presented in this booklet. It describes the advantages, corrosion resistance and heat treatment of these steels. Also included are data on high temperature properties and photographs showing typical applications.

(32) BIMETAL THERMOSTATS—Stevens Mfg. Co., Inc. Bulletin L-4079, 2 pp. Photographs showing terminal arrangements on various styles of bimetal strip thermostats used in refrigerators, electronic and avionic devices. Also schematic diagrams.

(33) LEATHER BELTING—E. F. Houghton & Co. Booklet, 18 pp. Illustrations, practical maintenance suggestions and engineering data for leather belting power transmission. Also belt formulae, and hp ratings.

(34) GAS-PIPE LINE PUMPING—General Electric Co. Booklet, GEA-5530, 16 pp. Information on use of a gas turbine for pipeline pumping. Illustrations, charts and operational curves. Breakdown view of components of turbine.

(35) ELECTRICAL TUBING—Republic Steel Corp. Booklet, 8 pp. Information on a new corrosion resistant electrical metallic tubing. Contains engineering data on immersion tests, strength, and other data.

(36) SOLENOID CONTACTORS—Ward Leonard Electric Co. Bulletin 4458, 4 pp. Illustrations and description of various pole form solenoid contactors. Contains cutaway views, circuit diagrams, and suggested usage.

(37) RIGIDIZED METAL — Rigidized Metals Corp. Booklet, 8 pp. Colored illustration giving information and applications of types of rigidized metal. Specifications and strength characteristics also given.

(38) FORGED STEEL PRODUCTS — Taylor Forge and Pipe Works. Catalog 501, 115 pp. Illustrates and describes forged steel nozzles, welding necks and large diameter flanges. Also included are data covering standards of the Tubular Equipment Manufacturers Association. A 44 page section covers flange design.

(39) OIL HYDRAULIC EQUIPMENT—The Commercial Shearing and Stamping Co. Catalogs H-3, H-4. These manuals give detailed information on the company's line of oil hydraulic cylinders and "D" series pumps and motors, respectively. Performance data, types of mountings, specifications and other engineering data are included.

(40) ELECTRONIC INSTRUMENTS — Potter Instrument Co., Inc. Booklet. Presents features, specifications and application data on high speed electronic counting, timing and control instruments.

(42) COIL SPRINGS—Dudek & Bock Spring and Mfg. Co. Bulletin, 4 pp. Gives information on the company's system for keeping cost of springs down. Included is a chart of manufacturing tolerances for coil springs.

(41) MASKING MATERIALS—The Kay & Ess Co. Booklet, 61 pp. Presents a compilation of reprints of articles from the Aug., Sept., Oct., and Nov. issues of "Products Finishing" covering modern masking materials and methods for fabrication and spray finishing. Included is information on the applications of pressure tapes, die-cut stencils, metal shields, electroformed masks, liquid masking materials and peelable plastic coatings.

(42) NON-FLAMMABLE HYDRAULIC FLUID—R. M. Hollingshead Corp. Booklet, 16 pp. Discusses the development, composition, properties and application of a non-flammable hydraulic fluid for aircraft. Included are charts showing the variation of viscosity, specific heat, thermal properties and specific gravity with temperature.

(43) J.I.C. PNEUMATIC STANDARDS —Miller Motor Co. Booklet, 12 pp. Reproduces in full the "J.I.C. Pneumatic Standards for Industrial Equipment." Included are sample circuit, glossary of terms, two pages of standard symbols and a comparison of the company's air cylinders with the standards.

(44) VARIABLE PITCH PULLEYS — Gerbing Mfg. Co. Catalog 651, 30 pp. Illustrations, descriptions and specifications for various variable pitch pulleys, drive arrangements and type of belt to be used. Also has engineering drawings of sample installations.

HOW TO ORDER—To request more information on any advertised item, jot down the page number of the ad and the initials of the advertiser. For new bulletins, circle the numbers.

Postage Will be Paid by McGraw-Hill Pub. Co.

No Postage Stamp Necessary if Mailed in the United States

BUSINESS REPLY CARD

First Class Permit No. 64, (Sec. 34.9, P. L. & R.) New York, N. Y.

Reader Service Manager
PRODUCT ENGINEERING
330 West 42nd Street
New York 18, N. Y.

PRODUCT ENGINEERING Not good after 11/1/51

Please send complete information about the products advertised on the following pages:
(Use initial of company if more than one advertisement appears on the page)

....

....

....

Send copies of the new bulletins and catalogs circled below to my attention.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49

Name..... Title .....

Company.....

Address..... 9/51

Contact KAYDON *of Muskegon*

FOR ALL TYPES OF BALL AND ROLLER BEARINGS 4" BORE TO 120" OUTSIDE DIAMETER

BIG PRECISION GRINDER

. . . calls for Big Precision Bearings

. . . and KAYDON *answers "O. K."*

KAYDON Double Row Taper Roller Bearing, 34.000" x 42.250" x 7.375", permits smooth, precision operation of the table spindle on the big 120" capacity double-head, heavy-duty super precision grinder shown at right.

THIS double head grinder permitted production of super precision accuracy in Naval gun mounts. It was designed to produce work of an angular accuracy of less than one-half thousandth (.0005") in 72", in flatness, squareness, concentricity, roundness and taper, and permitted interchangeability of gun mount parts which formerly were tediously hand scraped. Parts produced in regular production to an accuracy of .0002".

We believe this to be the world's largest, super precision industrial grinder, 26 of which were manufactured.

In heavy oil field machinery, ponderous steel-mill equipment, complicated paper-mill units . . . in rugged road-building machines, excavators, hoists, crushers . . . powerful bending machines, production units, and other industrial equipment . . . KAYDON bearings are improving performance and lengthening service-life. Look to KAYDON, Standard or Special, for the better bearing service your equipment deserves.

* * * *

Counsel in confidence with KAYDON. Capacity now available for all sizes and types of KAYDON bearings . . . and for atmospheric controlled heat treating, precision heat treating, salt-bath and sub-zero conditioning and treatment, microscopy, physical testing and metallurgical laboratory services.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

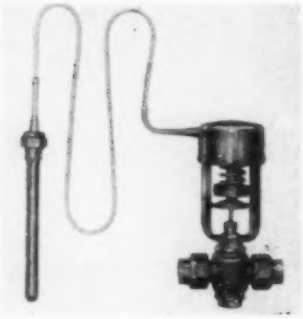
MUSKEGON • MICHIGAN

PRECISION BALL AND ROLLER BEARINGS

SPRING
Rx TONIC
We've been diagnosing spring problems for 61 years and industry has thrived on our prescriptions. Recommending the right springs for people like yourself is an old habit with American-Fort Pitt engineers. The American-Fort Pitt Springs that you specify will ease and speed assembly of your product and contribute to its good name. Mechanical springs is our specialty—and we produce them in a modern plant, employing advanced metallurgical techniques.
When it's spring time, give us a ring.
AMERICAN-FORT PITT SPRING DIVISION
H. K. Porter Company, Inc.
No. 2 John St., McKees Rocks, Pa. (Pittsburgh District)
AMERICAN-FORT PITT
SPRINGS

Temperature Regulator Has Long Life

An extra-large, two-ply metal Sylphon bellows in the thermal unit of a series of temperature regulators is said to provide added power for valve operation and to assure long service life. The regulators have press-formed frames of stainless steel, providing minimum heat conduction from the valve to regulator and assuring better



control, less weight and a reduction in over-all dimensions. Temperature ranges start at 40 F and end at 440 F.

Illustrated is the type of bulb used for liquids but supplied on order with fin-type bulb for air or gases. The No. 999 is available in valve sizes ½ to 4 in. inclusive, and with indicating thermometer and other special features to suit most any installation requirements. It is used for industrial process temperature control, storage water heaters, and internal combustion engine cooling, among others.

Robertshaw-Fulton Controls Co., Knoxville, Tenn.

Sealing Paint Applied Over Rusted Surfaces

A new penetrating and sealing antirust paint that can be applied over rusted surfaces, is said to be equally effective in preventing rust on new metal or stopping rust action on present rusted metal. The manufacturer advises that PCA-100 can be applied right over rust without extensive surface preparation such as wire brushing, scraping or sand blasting. Upon application, it penetrates through the rust layer into the base metal and seals the surface against further rusting. The paint is suitable for either brush or spray application.

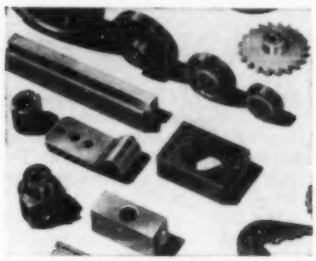
This paint is furnished in black only and, due to its penetrating characteristics, should be used solely as a "finish" coat. A companion product, PCA-101

Powder Metallurgy Parts Save Machining, Cut Costs

Adaptability of powder metallurgy processes to the die-forming of simple or intricate shapes to final dimensions has opened the way to substantial savings in the production costs of many types of machines and appliances. Close tolerances are maintained in "COMPO" and "POWDIRON" parts formed by powder metallurgy—without any need for expensive machining operations either at the parts fabricator's plant or during the assembly process. Incorporation of "COMPO" and "POWDIRON" parts in product designs eliminates metal waste in turning and boring operations, and frees manpower and machinery for other activities.

QUANTITY-ECONOMY CONSIDERATIONS

Dies for the production of "COMPO" and "POWDIRON" bearings are available in an extensive range of sizes, and most of the more widely used sizes of "COMPO" bearings are carried in stock. Since special sizes and shapes require special dies, the advantages of powder metallurgy for the production of such parts are particularly marked where quantity requirements are high. The initial cost of the die is then more than offset by subsequent production economies.



Intricate shapes like these are readily die-formed to final dimensions from "COMPO" and "POWDIRON."

FLEXIBILITY OF APPLICATION

"COMPO" and "POWDIRON" parts can be produced in a variety of compositions—with or without lubricant-retaining features—to meet different engineering requirements. All are characterized by the same ready-to-assemble dimensional accuracy that keeps costs down on the production line.

Information on "COMPO" and "POWDIRON" bearings and parts for specific applications may be obtained from Bound Brook Oil-Less Bearing Company, Bound Brook, N. J.

(Advertisement)

Low Installation Cost

is one of the 6* outstanding advantages of

"COMPO" and "POWDIRON"

BEARINGS AND PARTS

Powder metallurgy bearings and parts made of "COMPO" and "POWDIRON" are the *right* size when they reach you and the *right* size after they're installed—no costly machining needed after installation! Bearings are quickly, easily installed by a simple press fit—usually eliminate need for oil holes or grooves.

Stock sizes of "COMPO" bearings save you the *most* money—write on company letterhead for the latest list.

Send for this FREE Booklet

THE 6 OUTSTANDING ADVANTAGES OF "COMPO" AND "POWDIRON" ARE:

1. Low installation cost
2. Extreme quietness
3. Efficient lubrication
4. Low operating and maintenance cost
5. High load capacity at high speeds
6. Low unit cost

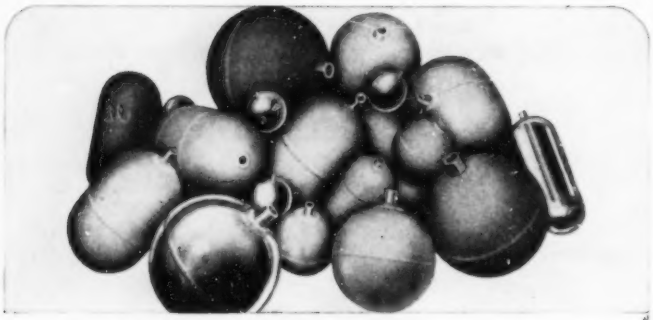
BOUND BROOK

"COMPO" • "POWDIRON" • "BOUND BROOK"

OIL-LESS BEARING COMPANY

BOUND BROOK, N. J. • BOUND BROOK 8-0341

ESTABLISHED 1883



Send for Nicholson

FLOAT BULLETIN 650

Complete Data on Welded Floats: Diagrams, Tables, Formulae for Calculating Buoyancies

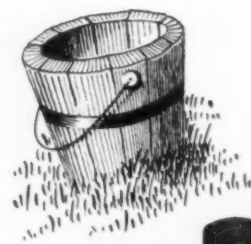
The booklet is a standard reference for specifiers of welded floats. Nicholson furnishes any type: for external or internal pressures; in stainless steel, Monel, chromium, cadmium or copper-plated steel. Sizes, 2" to 14" diam., press. to 4800 lbs.; standard or special connections. Quick delivery on many sizes and shapes. Nicholson floats are standard with hundreds of manufacturers.

W. H. NICHOLSON & CO., 200 Oregon St., Wilkes-Barre, Pa.

Sales and Engineering Offices in 55 Principal Cities

The

OLD OAKEN BUCKET



The old oaken bucket — full of green moss, brown lizards and rope drippings. That's the old way — some people are sentimental about it and they go around the country looking for one — but that's getting a drink the hard way.

You wouldn't want to live with an old oaken bucket — not for long. Why live with an old oaken bucket kind of tracing cloth, when you can get something as modern as Pel-X Water Repellent Tracing Cloth.

Sentiment is all right in its place — but that place isn't on a drawing board. Now is it?

Pel-X is modern — it's the best and we back up that claim with proof — your kind of proof — write for testing samples now — why not now?

THE HOLLISTON MILLS, INC.
NORWOOD, MASS.
NEW YORK PHILADELPHIA CHICAGO

Pel-X is backed by Holliston's 50 years of leadership and experience in developing special purpose cloths for industry.

is a clear paint, equally effective for rust prevention, and can be painted over with any standard paint of any color. Both finishes are available in one gallon and five gallon cans and in 55-gallon drums.

Paint Corp. of America, Fidelity Bldg., Cleveland 14, Ohio

Synchronous-motor Timer Features Wide Time Range

The SY "Promatic" synchronous-motor timer for accurate control of a wide variety of timed operations can be used for all time periods between $\frac{1}{2}$ sec and 24 hr. It actuates five single-pole, double throw load-contacts independent of the timer-control circuits. Two separate solenoids operate the clutch and timing mechanism and the load contacts, respectively. The timer automatically resets for each new cycle.

Mounted in a cast frame, long life is assured through a unique "O" ring-drive assembly which eliminates gears. The preset interval and the elapsed time are both visible on the $3\frac{3}{8}$ in. diameter dial.

The timer is available for either 115 or 230 v a-c operation. Outside dimensions: $4\frac{1}{2}$ in. wide, $4\frac{1}{8}$ in. deep, and 8 in. high, including terminal strips.

General Control Co., Boston 34, Mass.

New Solder Equals Galvanizing Protection

Damaged galvanizing, particularly where destroyed by welding, is restored by a galvanizing wire solder. This solder will withstand a 800 hr salt spray bath without deterioration,

"STANDARD" recommends STANDARDS*

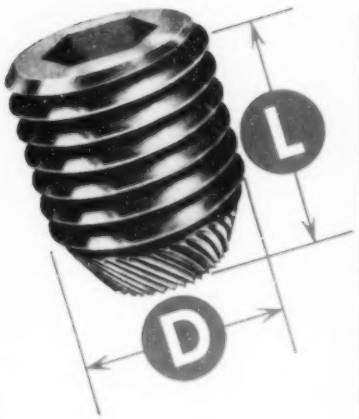
UNBRAKO®

SELF-LOCKING SOCKET SET SCREWS (WITH KNURLED CUP POINT)

STANDARD SIZES

Sizes preceded by asterisk (*) available in both National Coarse and National Fine Threads

Class 3 fit is an "UNBRAKO" standard



The unique, counter-clockwise *knurls* on the UNBRAKO Cup Point make these screws *self-locking*, prevent "creep" and subsequent loosening. And, UNBRAKO Set Screws with the Knurled Cup Point "stay put" even in poorly tapped holes — an important factor in reducing machinery stoppage and production losses.

★ **One of a series listing *Standard* UNBRAKO Socket Screw Products sold by your local UNBRAKO Distributor. If you want reprints of this and other advertisements in the series, ask for them on your business letterhead.**

Diameter	Threads per inch NC	Threads per inch NF	Overall Length	Price per 100	Quantity per box
#4 (.112")	40	48	* 1/8	3.95	100
	40	48	* 3/16	4.00	100
	40	48	* 1/4	4.05	100
	40	48	* 5/16	4.10	100
	40	48	* 3/8	4.20	100
	40		7/16	4.40	100
	40		1/2	4.70	100
	40		5/8	5.00	100
#5 (.125")	40	44	* 1/8	4.00	100
	40	44	* 3/16	4.05	100
	40	44	* 1/4	4.10	100
	40		5/16	4.15	100
	40		3/8	4.25	100
	40		7/16	4.45	100
	40		1/2	4.75	100
	40		5/8	5.05	100
	40		3/4	5.35	100
#6 (.138")	32	40	* 1/8	4.05	100
	32	40	* 3/16	4.10	100
	32	40	* 1/4	4.15	100
	32	40	* 5/16	4.20	100
	32	40	* 3/8	4.30	100
	32		7/16	4.50	100
	32		1/2	4.80	100
	32		5/8	5.10	100
	32		3/4	5.40	100
	32		7/8	5.70	100
	32		1	6.00	100
#8 (.164")	32	36	* 1/8	4.10	100
	32	36	* 3/16	4.15	100
	32	36	* 1/4	4.20	100
	32	36	* 5/16	4.25	100
	32	36	* 3/8	4.35	100
	32		7/16	4.55	100
	32	36	* 1/2	4.85	100
	32		5/8	5.15	100
	32		3/4	5.45	100
	32		7/8	5.75	100
	32		1	6.05	100
#10 (.190")	24	32	* 3/16	4.20	100
	24	32	* 1/4	4.25	100
	24	32	* 5/16	4.30	100
	24	32	* 3/8	4.40	100
	24	32	* 7/16	4.60	100
	24	32	* 1/2	4.90	100
	24	32	* 5/8	5.20	100
	24	32	* 3/4	5.50	100
	24		7/8	5.80	100
	24	32	*1	6.10	100
	24	32	*1 1/4	6.65	100
1/4 (.250")	20	28	* 3/16	4.30	100
	20	28	* 1/4	4.35	100
	20	28	* 5/16	4.40	100
	20	28	* 3/8	4.50	100
	20	28	* 7/16	4.70	100
	20	28	* 1/2	5.00	100
	20	28	* 5/8	5.35	100
	20	28	* 3/4	5.70	100
	20		7/8	6.05	100
	20	28	*1	6.40	100
	20	28	*1 1/4	7.10	100
	20		1 1/2	7.80	100
	20		1 3/4	8.50	100
	20		2	9.70	100
5/16 (.3125")	18	24	* 1/4	4.45	100
	18	24	* 5/16	4.50	100
	18	24	* 3/8	4.60	100
	18	24	* 7/16	4.80	100
	18	24	* 1/2	5.10	100
	18	24	* 5/8	5.50	100
	18	24	* 3/4	6.00	100
	18		7/8	6.50	100
	18	24	*1	7.00	100
	18	24	*1 1/4	7.60	100
5/16 (.3125")	18		1 1/2	8.40	100
	18		1 3/4	9.20	100
	18		2	10.50	100
3/8 (.375")	16	24	* 1/4	4.55	100
	16	24	* 5/16	4.60	100
	16	24	* 3/8	4.70	100
	16	24	* 7/16	4.90	100
	16	24	* 1/2	5.20	100
	16	24	* 5/8	5.60	100
	16	24	* 3/4	6.20	100
	16		7/8	6.80	100
	16	24	*1	7.40	100
	16	24	*1 1/4	8.20	100
	16		1 1/2	9.20	100
	16		1 3/4	10.50	100
	16		2	12.50	100
	16		2 1/2	14.50	100
7/16 (.4375")	14	20	* 3/8	5.90	100
	14	20	* 7/16	6.10	100
	14	20	* 1/2	6.40	100
	14		5/8	6.80	100
	14		3/4	7.40	100
	14		7/8	8.00	100
	14		1	8.70	100
	14		1 1/4	9.50	100
	14		1 1/2	11.00	100
	14		1 3/4	12.50	100
	14		2	14.00	50
	14		2 1/2	16.50	50
1/2 (.500")	13		3/8	6.90	100
	13		7/16	7.10	100
	13	20	* 1/2	7.40	100
	13	20	* 5/8	7.80	100
	13	20	* 3/4	8.40	100
	13		7/8	9.00	100
	13	20	*1	9.70	100
	13		1 1/4	10.50	100
	13		1 1/2	12.00	100
	13		1 3/4	13.50	50
	13		2	15.00	50
	13		2 1/2	17.50	50
	13		3	20.00	50
5/8 (.625")	11		1/2	9.90	100
	11	18	* 5/8	10.30	50
	11		3/4	10.90	50
	11		7/8	11.50	50
	11	18	*1	12.50	50
	11		1 1/4	13.50	50
	11		1 1/2	14.50	50
3/4 (.750")	10		5/8	12.80	50
	10		3/4	13.40	50
	10		7/8	14.00	50
	10		1	15.00	50
	10		1 1/4	16.00	50
	10		1 1/2	18.00	50
	10		1 3/4	20.00	50
	10		2	23.00	25
	10		2 1/2	27.00	25
	10		3	31.00	25
7/8 (.875")	9		7/8	17.00	25
	9		1	18.00	25
	9		1 1/4	20.00	25
	9		1 1/2	22.00	25
	9		1 3/4	25.00	25
	9		2	29.00	25
	9		2 1/2	34.00	25
	9		3	39.00	25
1 (1.000")	8		1	23.00	25
	8		1 1/4	25.00	25
	8		1 1/2	28.00	25
	8		1 3/4	32.00	25
	8		2	36.00	25
	8		2 1/2	42.00	25
	8		3	48.00	25

Prices subject to change without notice.

LIST PRICES SUBJECT TO DISCOUNT

Most tapped holes are *standard*, why specify "special" screws? Use UNBRAKO *standards!*

SPS

STANDARD PRESSED STEEL CO.

JENKINTOWN 20, PENNSYLVANIA

Laminated shims peel off in .002" layers for adjustment purposes and thus provide a variable spacing device in the assembly of machinery components.

Laminated shims represent sound design and engineering practice. They meet the acid tests of speeded production, lowered costs and field performance.

Today the health of our economy—and the reputation of an individual business—can depend upon a relentless search for time and money-saving methods.

Here are the basic features of shim design:

- .002 inch accuracy with easy machining tolerances
- up to 30% reduction in assembly time
- spacing adjustment at the job without precision grinding or machining
- a built-in adjustment for take-up of service wear

We're going at top speed working on the defense program. Whether we can help you now—or whether you're just thinking of long range economies, send for our free Engineering Data File.

Save wisely wherever you can!
Shims are more important now than ever.

LAMINATED SHIM COMPANY
INCORPORATED
CUSTOM SHIMS SHIM STOCK STAMPINGS

1409 UNION STREET GLENBROOK, CONN.

the requirements of a good hot dip job. (2) It shows no line of demarcation between it and hot dip, but makes a homogenous coat. (3) It has a melting point only 17 F higher than 50/50 and has a high degree of fluidity. It may be applied successfully with torch or soldering iron and may be used on steel, iron, brass, copper, galvanize, and terne plate. This combination is said to be highly effective on underground connections, refrigerators, ship's ventilators and many other applications.

Farrelloy Co., 1245 N. 26th St., Philadelphia 21, Pa.

Air & Gases Cleaned By Ceramic Filters

Large volumes of compressed air and other gases contaminated with water, free oil, water-oil emulsions and dirt are cleaned in a recently manufactured series of liquid ejectors.

These ejectors deliver clean air-gas continuously to instrument or pneumatic systems through specially prepared liquid-impervious ceramic filters. Liquids and dirt are ejected automatically. These devices have no moving parts.

Selas Corporation of America, Erie Ave. and D St., Philadelphia 34, Pa.

Electronic Timer Used For Welding

An electronic timer type 30CR3 has been constructed for controlled short interval timing. The timing adjustment is calibrated for any interval from 3 to 120 cycles, and the accuracy throughout this range is within 2 percent.

In addition to its general purpose timing applications, Type 30CR3 may be used for spot welders and is applicable to manual, air or motor operated welding equipment requiring either

Rubber Parts

WEATHER RESISTANT STOCKS

	Before Aging				After Aging (* — 70 hrs. @ 212° F. † — 70 hrs. @ 158° F.)		
STOCK NUMBER	DUROMETER HARDNESS Shore A Scale	TENSILE STRENGTH p.s.i.	ELONGATION per cent	LOW TEMP. °F (5 hr. test)	DUROMETER HARDNESS Shore A Scale	TENSILE STRENGTH p.s.i.	ELONGATION per cent
408	60	2232	350	—70	156	1951	475
307	65	2618	360	—70	†68	2344	325
526	58	2855	420	—70	†60	2997	400
566	79	1566	250	—70	†84	1706	215
720	60	2284	380	—50	*80	1952	228
822	60	2285	350	—50	*62	2239	433
823	80	2081	235	—50	*82	2016	175
847	50	1569	348	—50	*60	2000	338

*A.S.T.M. D746-44T

Stocks listed above are only representative of the many compounds available.

Featuring resistance to sunlight, ozone, freezing temperatures and salt air, STALWART-compounded weather-resistant rubber stocks are available in mass produced parts for application in aircraft, automobiles, trucks, marine equipment, electrical assemblies and railroad rolling stock.

Whether they are to withstand dry desert heat and burning sunlight or the prolonged damp cold of artic regions, these newly developed rubber stocks can be supplied in precision molded, extruded, die-cut, or lathe-cut shapes having varying degrees of hardness, tensile strength and elongation to meet the demands of specific applicctions.

In addition to weather resistance, these parts can have the capacity for withstanding other deteriorating forces such as abrasion, compression and chemical action. For applications involving extreme temperatures as low as —110° and as high as +500° Fahrenheit, parts can be fabricated from Silicone Rubber Compounds.

STALWART is prepared to meet individual requirements as well as S.A.E. and A.S.T.M. specifications. Write today for the new 16-page illustrated catalog No. 51SR-1.

152-SR

STALWART RUBBER COMPANY

9166 NORTHFIELD ROAD • BEDFORD, OHIO

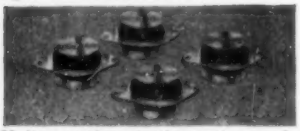
SHOCK and VIBRATION NEWS

BARRYMOUNTS FOR ASSURED CONTROL OF SHOCK AND VIBRATION

SMALL PLATE-TYPE BARRYMOUNTS

for Mounting Light Industrial Equipment

New Series 6300 Barrymounts are designed to fill the need for plate-type vibration isolators requiring little mounting space and carrying light to moderate loads.



Unit mountings in this series can be furnished with load ratings as low as one pound and up to 11 pounds. The free height of the top of the unit mounting, above the central mounting plate, is approximately 23/64 inch. The symmetrical design permits loads to be applied either axially or radially, or with components in both directions.

Designed primarily as vibration isolators, the Series 6300 units have a transmissibility of about 6 at resonance, which occurs at approximately 15 cycles per second under rated load. Vibration isolation at 30 cycles or above is extremely efficient. The stability of the mounting is excellent, and transient shock isolation is satisfactory for the intended service.

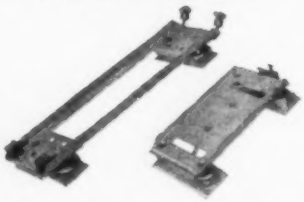
These new Barrymounts are available in two mounting styles: Series 6300, with two holes on 1-13/32 inch centers, and Series 6780, with four holes at the corners of a one-inch square. Detailed ratings, performance data, and dimensions are given on Data Sheet 608. Write for your free copy today!

FREE CATALOGS

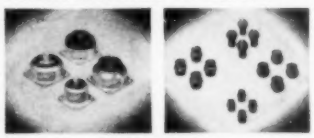
- 502 – Air-damped Barrymounts for aircraft service; also mounting bases and instrument mountings.
- 509 — ALL-METL Barrymounts and mounting bases for unusual airborne applications.
- 504 — Shock mounts and vibration isolators for marine, mobile, and industrial uses.
- 607 — How to cut maintenance costs by using Barrymounts with punch presses.
- 605-606 — Miniaturized air-damped Barrymounts for use with airborne equipment.

STANDARD MOUNTINGS ISOLATE VIBRATION

Available for Aircraft, Marine, Mobile, Instrument, and Industrial uses.

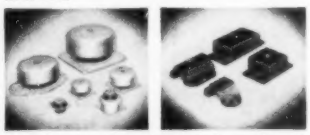


Standard bases built to meet government specifications can be furnished by Barry; special bases can be supplied in sizes and load ratings to fit customers' exact requirements, including miniaturized bases. See catalog 502 and data sheets 605 and 606.



Aircraft vibration isolators designed to meet Army, Navy, and CAA requirements are available in ¼-pound to 45-pound unit ratings; also miniature mounts to 0.1 lb. See catalogs 502 and 509 and bulletins 605-6.

Instrument mountings are furnished for electronic components, tiny, fractional-HP motors, record changers, dictating machines, and other lightweight apparatus. See catalogs 502 and 504.



Shock mountings for mobile, railroad, and shipboard service also give vibration isolation at frequencies above 2000 c.p.m.; useful for general sound isolation. See catalog 504.

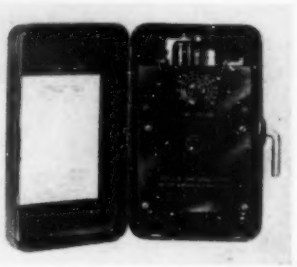
Industrial mountings isolate vibration from fans, motor-generator sets, transformers, punch presses, and other heavy industrial equipment. Bulletin 607 tells how to cut maintenance costs with Barrymounts.

THE **BARRY** CORP.

730 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

New York Rochester Philadelphia Washington Cleveland Dayton Detroit
Chicago Minneapolis St. Louis Seattle Los Angeles Dallas Toronto



beat or non-beat operation. It is also used for automatic filling operations in the food and drug industries, the control of punch presses and other machine tools, and conveyor control.

The timer may be used with either a 115 or 230 v a-c, 50–60 cycle supply. By selection of terminals on the terminal panel, the timer will provide "beat" or "non-beat" operation. The terminal panel is provided with a bakelite dead-front. Overall dimensions are: $9\frac{5}{8}$ x $6\frac{3}{4}$ x $4\frac{7}{16}$ inches. Other specifications are: ambient temperature, 32 to 150 F; ambient relative humidity 20 to 95 percent.

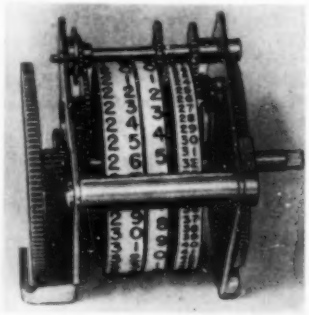
Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.

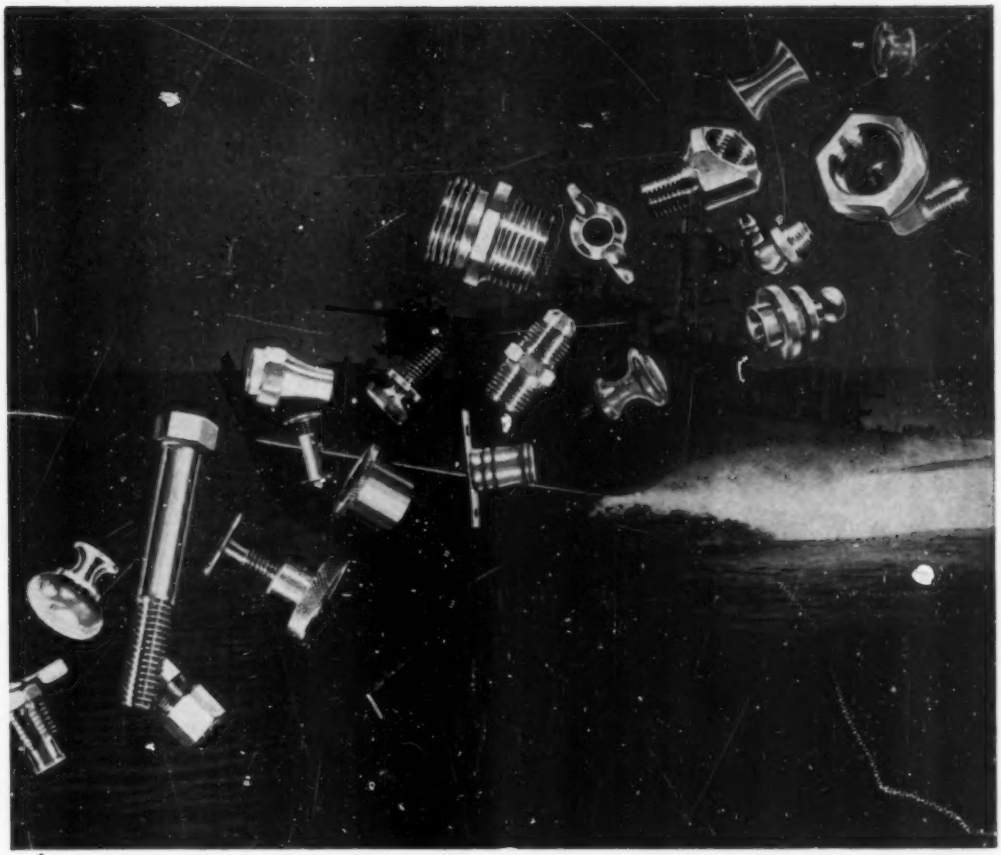
Counter Shows Degrees and Minutes of Angle

A special counter developed to show degrees and minutes of angles can be used forward or backward for any number of 360 deg rotations since it transfers from 359 deg 59 min to 0 deg 00 min.

The minute readings are on the 60 place wheel to the right. The middle wheel repeats three time the numerals from 0 to 9, while the left hand wheel reads 0 to 35 on one rotation. Transfer from the minute wheel occurs in 5 min of reading. The output shaft gives 5 deg of reading per rotation.

This unit was developed especially to replace a vernier type reading on





To bring America more of these...

KAISER ALUMINUM'S rod and bar plant at Newark, Ohio, is supplying increasing tonnage of aluminum screw machine stock to American industry.

At the same time, we are helping to meet the critical need for more forging stock, as well as for all types of aluminum wire. We are providing the alloys to meet government specifications for scores of essential products . . . from rivets to screw fasteners, from jet engine impellers to hand tools.

Our engineering and technical knowledge acquired in these varied fields may help you.

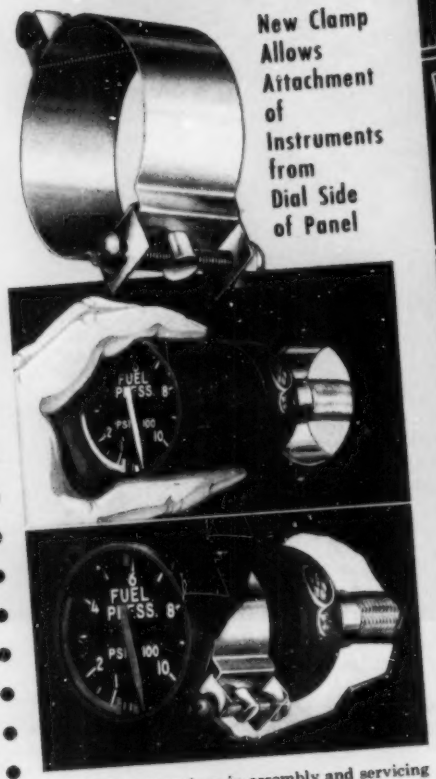
Sales offices in principal cities. Kaiser Aluminum & Chemical Sales, Inc., Oakland, California.

Kaiser Aluminum

Setting the pace—through quality and service

ENGINEERS' NOTEBOOK

New Clamp Allows Attachment of Instruments from Dial Side of Panel



Significant savings in assembly and servicing time are achieved by Marman Products' new instrument mounting clamp. The clamp is installed on the rear of the panel but mounting or removing is easily accomplished from the dial side of the panel by adjusting only one clamp actuator screw.

Marman part No. 23906 clamp conforms to specification MIL-C-6818 and is installed in accordance with Specification MIL-C-6822.

Save Cost, Time and Weight with Marman Standard Clamps for Special Applications

FOR INFORMATION, WRITE DEPT. E-9

MARMAN PRODUCTS CO. INC.

940 WEST FLORENCE AVENUE

INGLEWOOD, CALIFORNIA

certain equipment where the Air Forces found that too many errors in data resulted from requiring relatively inexperienced men to make rapid vernier readings.

Mast Development Co., 2212 E. 12th St., Davenport, Iowa

Miniature Rotary Switch Is Precision Made

A new miniature rotary switch, developed to meet the requirements of miniaturization in airborne electronic equipment such as communication receivers, telemetering equipment and guided missile controls is now commercially available. Ganging, one two or three pole switches offer many combinations for complex circuits. Insulation between shaft and contact arms will withstand 2,500v a-c.

The diameter of the switch is $\frac{5}{8}$ in., and the switch body is $\frac{3}{16}$ in. thick. Plastic parts are compression molded of Plaskon Alkyd, which is said to be 9 times more resistant to arcs than the commonly used phenolics. Contacts are of pure silver and the contact arm is silver plated beryllium copper, heat-treated for maximum strength and reliable operation.

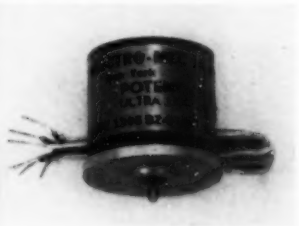
Electronic Development Corp., 6014 Washington Blvd., Culver City, Calif.

New Potentiometer Is Simple, Compact

Precision potentiometer with two electrically separate sections is applicable to devices where an exceedingly small mechanical force must be converted into two equivalent electrical voltages.

Originally developed to overcome a space and weight problem in a guided missile, this new instrument has a shaft torque as low as 0.013 oz. The two-in-one design features make these potentiometers well suited for aircraft and industrial instruments.

Current carrying capacities up to 100 milliamperes provide two outputs sufficient to operate simultaneously controlling and recording or indicat-



PRECISION TURNING POINTS

for tiny shafts

For extremely small shafts in fractional h.p. motors, instruments, home appliances, cameras and projectors, Fafnir makes several series of *extra small ball bearings* . . . in metric bore sizes down to 4 mm and in inch sizes down to ⅛".

The advantage of these small bearings show up in several ways. For the portable converter illustrated, they assure instantaneous, dependable response no matter how long it has remained idle. Bearing lubrication is eliminated . . . under normal conditions. Shaft wear reduced to a minimum.

Fafnir Extra-Small bearings are available with standard, special or super-precision tolerances . . . in various constructions. They can be fitted with grease shields, Mechani-Seals or Plya-Seals.

An important reference catalog

The new Fafnir Instrument Ball Bearing Catalog provides valuable data on dimensions, load ratings, tolerances, mountings etc. Also information on ball bearing standards and illustrations of typical applications. Send for a copy. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

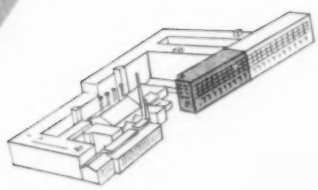
MOST COMPLETE LINE IN AMERICA

★ PROGRESS REPORT

DOING OUR BEST

To try to keep abreast of an unprecedented demand for Fafnir Ball Bearings we're doing our best to provide greater production facilities.

One phase of this expansion program is the recently completed, 6-story modern addition to the main Fafnir Plant. It adds 70,000 square feet of manufacturing space to the 750,000 previously included in the 4 Fafnir Plants . . . now, almost 19 acres.



where HARD RUBBER is right...
use it!
how to
SIMPLIFY DESIGNS
6-HOLE
ELECTRICAL
CONNECTOR
with
ACE®
extruded hard rubber
SAVES
MACHINING
MOLD COSTS
Just conjure up the right hard rubber extruded shape, and the job of making many a small part is half done! The electrical connector above, for example. For good electrical properties, stability and strength, it's made of ACE hard rubber rod with the six holes extruded right in it. Simply cut it off to length, soften by heating, press in the metal inserts, and presto! An amazing variety of shapes and compounds of ACE Hard Rubber are possible, even extruded directly over metal rods and tubes. Machines and finishes as easily as brass. Stir your imagination? Write for more facts today.
Keep your ACE Hard Rubber and Plastics Handbook handy. Free on request. It's a gold mine of hints like these.
100th
ANNIVERSARY
American Hard Rubber Company
93 WORTH STREET • NEW YORK 13, N. Y.

ing instruments without amplification; resulting in substantial savings in size, weight, and complexity.

The design provides for great flexibility to meet the needs of individual specifications. The two resistor sections are offered in values between 50 and 60,000 ohms each and with accuracies within 0.065 percent. Satisfactory operation at vibration frequencies up to 425 cycles per sec has been verified by actual flight tests.

Miniature precision ball bearings, or sapphire jewel bearings insure high performance characteristics and long service life. All parts are of non-corrosive materials or are suitably protected by plating or anodic treatment.

Approximately 1¾ in. long by 1¼ in. in diameter and with a 0.078 diameter shaft, the instrument weighs only 0.79 oz. Color coded wire leads provide the electrical connections.

Electro-Mec Lab., 225 Broadway, New York 7, N. Y.

Phenolic Molding Material Has Good Impact Strength

A phenolic impact molding material called RX-429 has been developed with an impact strength of 0.8. RX-429, a dustless, black material, may be automatically preformed on any standard tabletting machine, and preforms can be held to close tolerances.

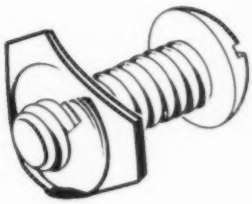
The material, which has a fast rate of cure, can be compression-, transfer-, or plunger-molded. Typical properties include the following: apparent density, 0.38 (min); compressive strength, 22,000 psi (min); izod impact strength (milled notch in side), 0.8 ft lb/in. of notch (min); compression molding pressure, 4,000 psi (min); molding shrinkage 0.005–0.007 in./in.; heat distortion point, 300 F (min).

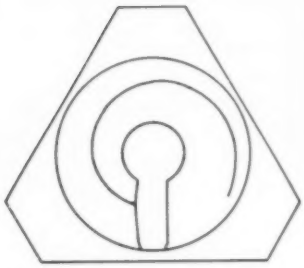
Rogers Corp., Manchester, Conn.

New Truarc Retainer Acts as Secure Self-Locking Nut

A new type of retainer has been designed to act as an economical self-locking nut on threaded shafts. Designated as Truarc series 5,300, the new triangular shaped retaining nut has a drawn helical segment with a tapered inner edge that forms a single thread conforming with American Standards.

When screwed on a threaded shaft, the dished triangular body flattens under torque and secures an equal load distribution against the part



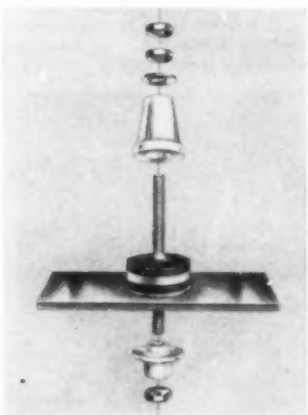


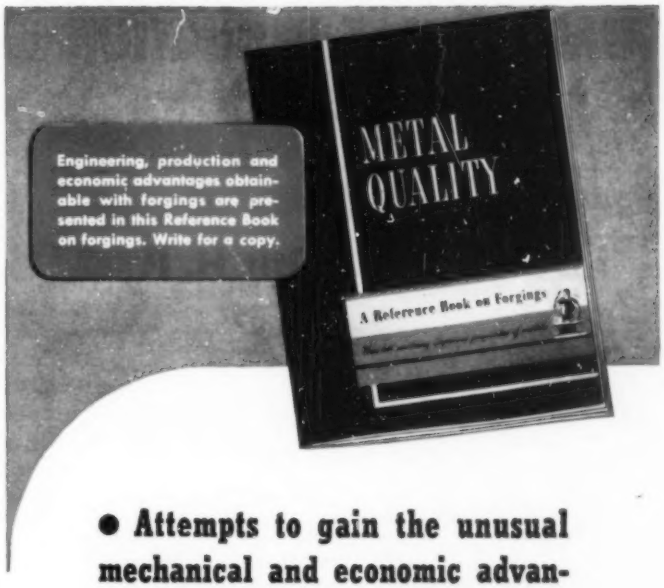
being held. Separate washers are unnecessary. Under spring tension, the threaded helical segment engages the full depth of the circumference of the screw thread approximately 300 degrees. The retaining nut will remain secure under impacts and vibration.

Waldes Kohinoor, Inc., 47-16 Austel Pl., Long Island City 1, N. Y.

Fluoro-Carbon Resins Sealed Hermetically to Metals

Fluoro carbon resins can now be sealed hermetically to any one of several metals and withstand vibration, shock, high and low ambient temperature limits and thermal shock. A broad range of electrical conditions ranging




Engineering, production and economic advantages obtainable with forgings are presented in this Reference Book on forgings. Write for a copy.
METAL QUALITY
A Reference Book on Forgings

● Attempts to gain the unusual mechanical and economic advantages of closed die forgings without using forgings seldom meet with success. There is no substitute for the combination of strength and toughness inherent in the compact fiber-like flow line structure of forgings. Consult a Forging Engineer about how you can obtain a correct combination of mechanical qualities in forgings for your particular type of equipment.

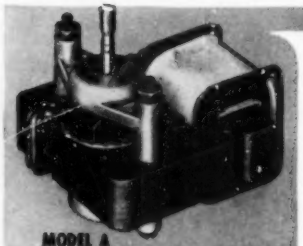
DROP FORGING ASSOCIATION
605 HANNA BLDG. • CLEVELAND 15, OHIO

Please send 60-page booklet entitled "Metal Quality — How Hot Working Improves Properties of Metal", 1949 Edition.

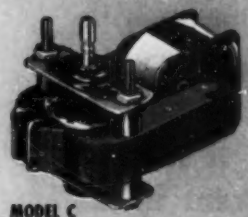
Name .....
Position .....
Company .....
Address .....

SHADED-POLE INDUCTION motors

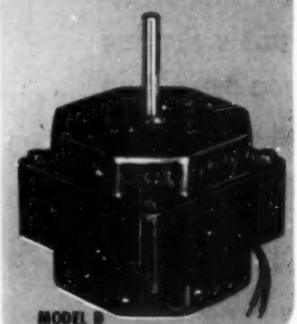
1/50th to 1/500th H. P.



MODEL A
2-pole . . . 1/125th to 1/500th H. P.



MODEL C
2-pole . . . 1/250th to 1/500th H. P.



MODEL D
4-pole . . . 1/30th to 1/100th H. P.

features

Enclosed self-aligning oil-less sleeve bearings

Internal cooling fans

Insulated connecting leads

Well insulated covered coils

Symmetrical electrical and mechanical design

Precision construction

Trouble-free and quiet operation

These famous *Smooth Power* Small Motors meet every requirement for dependable, trouble-free performance. Write *today* for complete information, specifications and quantity price quotations.

THE GENERAL INDUSTRIES CO.
DEPARTMENT D • ELYRIA, OHIO

from insulator to semi-conductor, to low resistance conductor and radio frequency shield, or any combination of these may also be obtained.

Best described as a fused seal capable of holding a vacuum for sustained periods, this seal gradually changes from a pure fluoro-carbon resin to a pure metal. Various types of terminals, printed circuits or metal faced Teflon sheets, rods or cylinders are available for particular problems.

U. S. Gasket Co., Teflon Products Div., P. O. Box 93, Camden 1, N. J.

Tachometer Monitors Speeds Of Several Machines

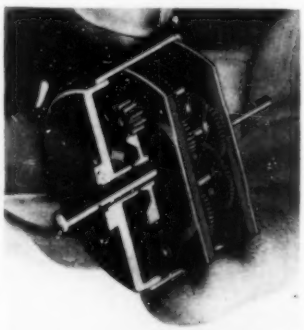
The speeds of several machines may be measured from one location, with this tachometer, which employs a simple machine selector knob. Speed tests and comparisons may be accomplished, with the indicator located up to 1,000 ft from any of the machines.

A selection of 50 standard full scale range markings are available. Direct reading in any units, such as rpm, fpm, in. per sec, loaves per hr, from speeds between 1/10 rpm and 100,000 rpm are offered. No speed changing drives are required. Connections between heads on the machines and the indicator are made by ordinary electric wiring. Sealed construction assures dust proof operation. The meter is mounted in sponge rubber, and overspeeding does not damage the indicator.

Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.

Light Load Gear Trains Are Sealed, Self-Oiling

These sealed, self-oiling gear trains come in a variety of standard speed-changing ratios for output shaft torque loads up to 0.375 lb-in. The standard ratios range from 7,200:1 to 25:1.

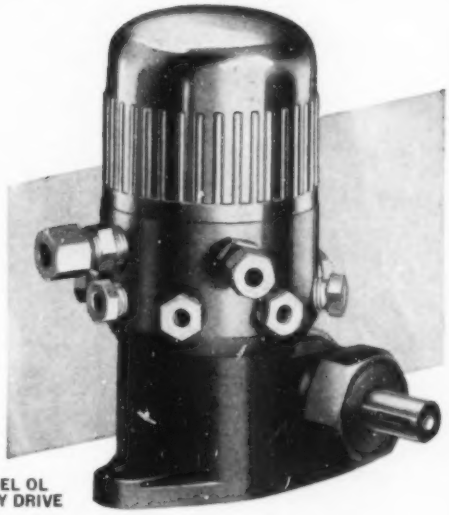


PRODUCT

MADISON-KIPP LUBRICATORS

Fresh Oil FED UNDER PRESSURE BY THE MEASURED DROP

The Model OL is the smallest in the series of six MADISON-KIPP lubricators. It is used where space is limited and for built-in applications in separated units of machinery where the most reliable type of lubrication is vital.



MODEL OL ROTARY DRIVE

PROCESS

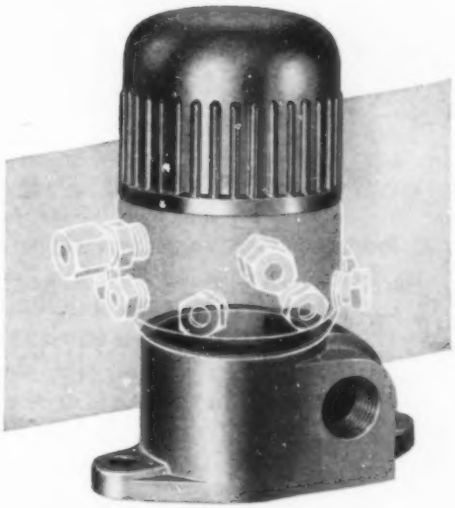
MADISON-KIPP DIE CASTINGS

IN ZINC AND ALUMINUM

Die castings as illustrated provide two important functions in the OL lubricator. They combine economical basic parts with pleasing appearance.

When you are designing new products, do not overlook the advantages of the die casting process.

Please send all your inquiries to the home office in Madison, Wisconsin.



MADISON-KIPP CORPORATION

206 WAUBESA STREET, MADISON 10, WIS., U.S.A.

ANCIENS ATELIERS GASQUY, 31 Rue du Marais, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS

Whether you need a tote box full of parts—or box cars full—we can produce them. We'll take designing, tooling, and other chores off your hands, too. If you need parts with the excellent characteristics of Plaskon Alkyd, our fact-and-figure men are eager to talk with you. Just write, wire, or phone. Or if you prefer, our plane and pilot will speed you here for a time-saving chat about your parts problems. No obligation, of course.

PRP

Other ratios as high as 216,000 to 1 may be obtained, depending on the load involved.

In addition to their sealed, self-oiling design, these gear trains utilize hobbed gears only for accurate, quiet operation and long life in applications calling for the transmission of small amounts of power.

Telechron, Inc., Ashland, Mass.

Dual-Channel Oscilloscope Shows Tracings From 0 To One Megacycle

A new dual-channel oscilloscope has been announced which features a flat frequency response from d-c to 1 megacycle. The use of two independent channels working into a single two-gun cathode ray tube permits high or low frequency phenomena to be viewed either singly or simultaneously on a single tube face. Dual-channel versatility and wide frequency range are combined, making two instruments in one.

The vertical deflection amplifiers have capacitive and conductive input attenuators, allowing operation as either a-c or d-c coupled amplifiers. Each channel is supplied with an independently operating sweep generator. Both channels may be switched to the same sweep, allowing the examination of two related phenomena on a common time base. The sweep generators are designed for either single sweep or recurrent operation. Independent control of intensity, focus and positioning of each of the electron beams is available.

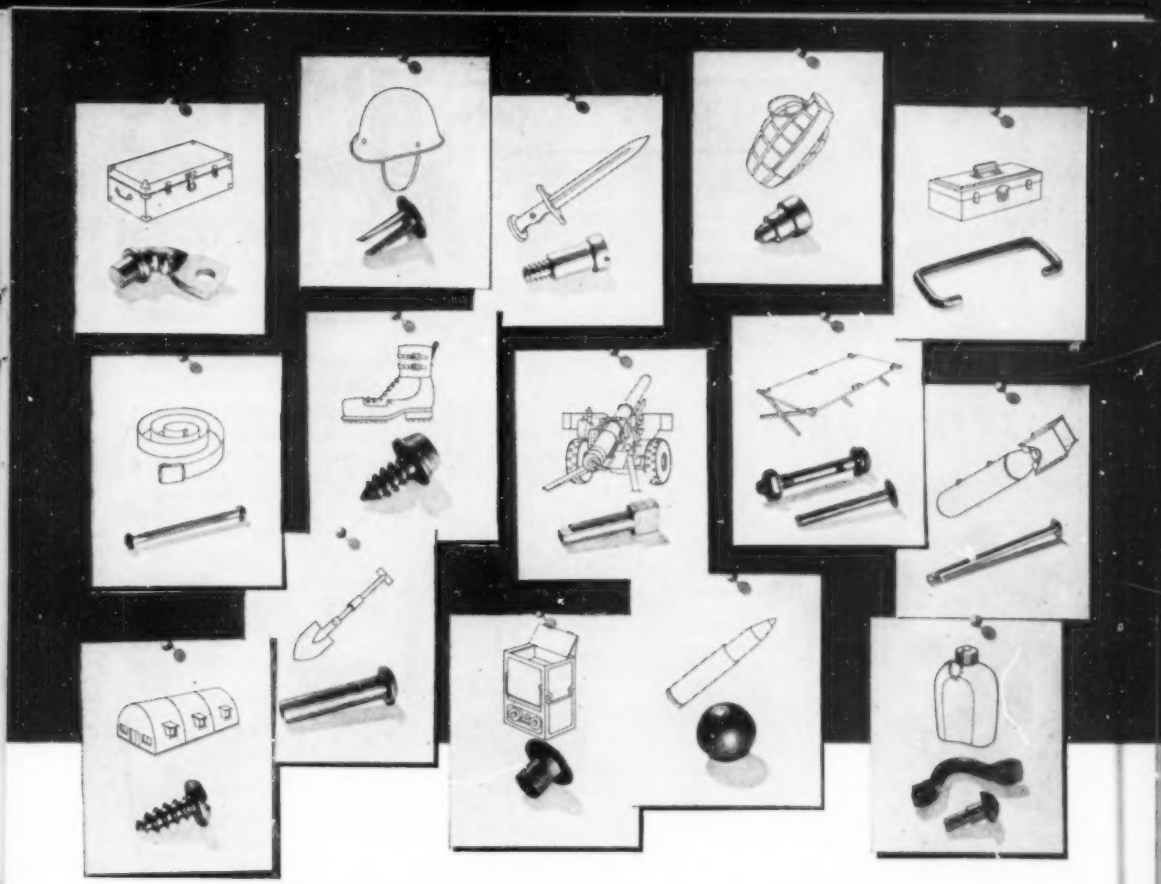
Electric Tube Corp., Philadelphia, Pa.

Finger-Tip Motor Control Unit

A speed control mechanism, consisting of a special motor and a companion control box operating from a 115 v 60 cycle line has been designed to provide finger-tip control of motor speed from 50 to 5,000 rpm. A meter, calibrated in rpm gives the motor speed.

The action of the control is to maintai the speed approximately constant at the setting determined by the control knob, regardless of variations in the load. The motor will deliver up to 10 in. oz of torque at any speed between 50 and 5,000 rpm.* It may be used as the drive in coil winding machines and machine tools.

Industrial Control Co., Wyandanch, L. I., N. Y.



With Townsend Fasteners and Parts you produce defense items with economy and speed

You reduce costs and speed delivery of military items by calling upon Townsend's past experience in producing special fasteners and parts for all types of Army and Navy material.

Townsend has made parts for a multitude of items from rivets for cots and beds to balls for artillery canisters — from hob nails for field boots to rivets for half track treads — from sheet metal screws for Quonset huts to pins and burrs for pup-tent poles — from special nails for gliders to large rivets for tanks — from handles for tool chests to screws for bayonets —to name but a few.

As specialists in cold heading, Townsend has demonstrated to customers everywhere the economy of parts made by the cold-heading process. It is fast, accurate and ideally suited to volume production. It also conserves metal because in this process the metal flows into shape—there are no waste shavings and chips.

As a result, Townsend produces small parts and fasteners at costs far below screw machine prices—and makes them faster. This saving in time and money may give you an advantage in bidding on government contracts. To learn more about the economy of using Townsend products, write or phone today.

Townsend

COMPANY • ESTABLISHED 1816

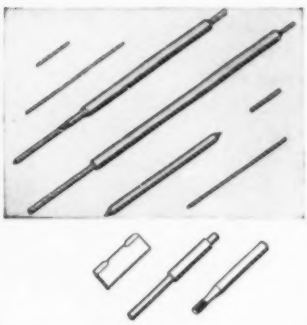
Plants: New Brighton, Pa. • Chicago 38, Ill.
Cherry Rivet Company Division, Los Angeles, California

Sales Offices in Principal Cities

SAVE

on metal parts made to your prints by

TORRINGTON



Special equipment and volume production enable us to save for you on a wide variety of precision metal parts.

For example, special shafts and pivots are made to order for meters, instruments, speedometers, tachometers, etc. Sharp, concentric, ground or swaged single or double points. Diameters .015" to 5/16". Lengths 3/16" to 10".

We are also set up to make such parts as special needles, rollers, shafts, studs, dowel pins, surgical and dental instruments, pen and pencil barrels, knurled mandrels and spindles, screw driver and ice pick blades, etc.

Send your prints and specifications today for a prompt quotation.

THE TORRINGTON COMPANY
Specialty Department
554 Field Street • Torrington, Conn.

Makers of
TORRINGTON NEEDLE BEARINGS

MEETINGS

September 5–7

AMERICAN HOT DIP GALVANIZERS ASSOCIATION—Semi-Annual Meeting, Greenbrier Hotel, White Sulphur Springs, W. Va.

September 10–13

SOCIETY OF AUTOMOTIVE ENGINEERS—Tractor and Production Forum, Schroeder Hotel, Milwaukee.

September 10–14

INSTRUMENT SOCIETY OF AMERICA—Sixth National Instrument Conference and Exhibit, Sam Houston Coliseum, Houston, Texas.

September 26–28

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Fall Meeting, Hotel Radisson, Minneapolis, Minn.

October 9–12

SCIENTIFIC APPARATUS MAKERS ASSOCIATION—Midyear Meeting, Recorder-Controller Section, Seaview Country Club, Absecon, N. J.

October 11–12

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Technical Conference on Fractional Horsepower Motors for Refrigerating Equipment and Pumps, Dayton Biltmore Hotel, Dayton, Ohio.

October 15–19

NATIONAL METAL EXPOSITION & CONGRESS—Michigan State Fairgrounds, Detroit, Mich.

October 18–19

SCIENTIFIC APPARATUS MAKERS ASSOCIATION—Midyear Meeting, Industrial Instrument Section, Seaview Country Club, Absecon, N. J.

October 22–24

NATIONAL STANDARDIZATION CONFERENCE—Second Annual Meeting, Waldorf-Astoria Hotel, New York.

October 22–24

AMERICAN STANDARDS ASSOCIATION—Thirty-Third Annual Meeting, Waldorf-Astoria Hotel, New York.

October 22–24

NATIONAL ELECTRONICS CONFERENCE—Seventh Annual Conference, Edgewater Beach Hotel, Chicago, Ill.

October 29–31

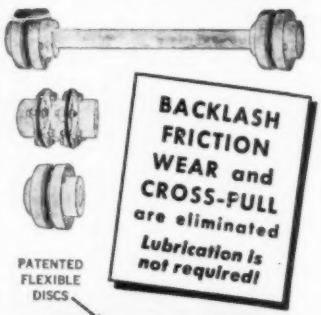
AMERICAN GEAR MANUFACTURERS ASSOCIATION—Semi-Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

THOMAS
Flexible ALL METAL
COUPLINGS
FOR POWER TRANSMISSION
REQUIRE NO MAINTENANCE

Patented Flexible Disc Rings of special steel transmit the power and provide for misalignment and end float.

Thomas Couplings have a wide range of speeds, horsepower and shaft sizes:
½ to 40,000 HP
1 to 30,000 RPM

Specialists on Couplings for more than 30 years



THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT.

NO MAINTENANCE PROBLEMS.

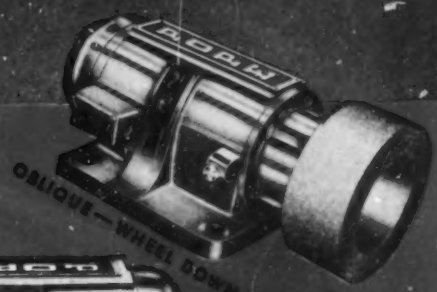
ALL PARTS ARE SOLIDLY BOLTED TOGETHER.

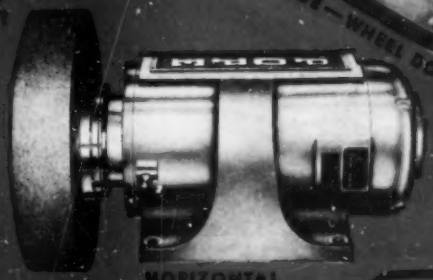
Write for the latest reprint of our Engineering Catalog.

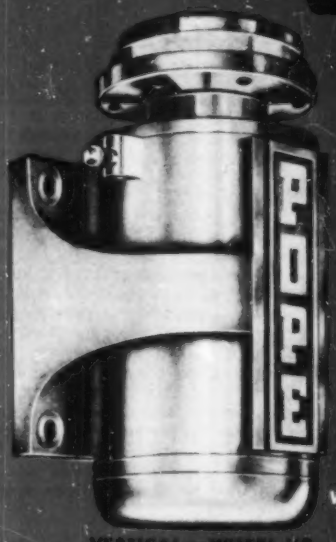
THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

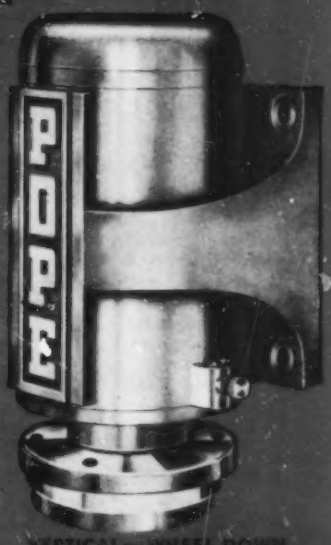
Specify POPE

2500 SERIES—HEAVY DUTY MOTORIZED SPINDLES









FOR MORE PRODUCTION—BETTER SURFACE FINISHES

use these P-2500 Series Spindles. They have the extra power, bearing capacity and rigidity to do the job better.

Adapted for use on surface grinders, planers, boring mills and other machine tools.

Write for new Catalog No. 58A

POPE

TRADE MARK REG. U.S. PAT. OFF.

POPE MACHINERY CORPORATION

ESTABLISHED 1920

261 RIVER STREET • HAVERHILL, MASSACHUSETTS

BUILDERS OF PRECISION SPINDLES

TROSTEL *Engineered*

THREE separate and distinct laboratories to solve your sealing problems

Good packings design requires exact answers to specific hydraulic, pneumatic, or fluid retention problems with rubber or leather.

Supplying these facts is the important function of Trostel research—supplying them out of experience wherever possible; developing new compounds and impregnations where existing materials are found wanting.

The end result is a thoroughly tested design based on known operating data; one that can be produced economically, in quantity, under rigid laboratory control.

We invite you to join the many well-engineered companies who have found these services both indispensable and profitable.

Illustrated bulletin on request.

LEATHER LABORATORY

SYNTHETICS LABORATORY

IMPREGNATIONS LABORATORY

ALBERT TROSTEL & SONS COMPANY
Packings Division • Milwaukee 1, Wisconsin
Since 1858

TROSTEL engineered PACKINGS

ENGINEERING ABSTRACTS

Two Starters for Low Inrush Current

From "Cushion Starting of A-C Motors", by H. L. Lindstrom, Control Engineer, Westinghouse Electric Corp. A paper presented at the 15th Annual Machine Tool Electrification Forum in Pittsburgh, Pa., April 10 and 11, 1951.

THE STAR-DELTA STARTER, used with a motor whose windings are delta-connected for running, connects the windings in star for starting—as illustrated in Fig. 1. The voltage across each winding is reduced in the ratio

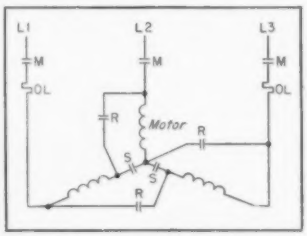


FIG. 1—Star-Delta Starter.

of 1/1.732, and the line current is reduced to $\frac{1}{3}$ of that drawn with the delta connection. A fixed torque of approximately $\frac{1}{3}$ of normal is obtainable.

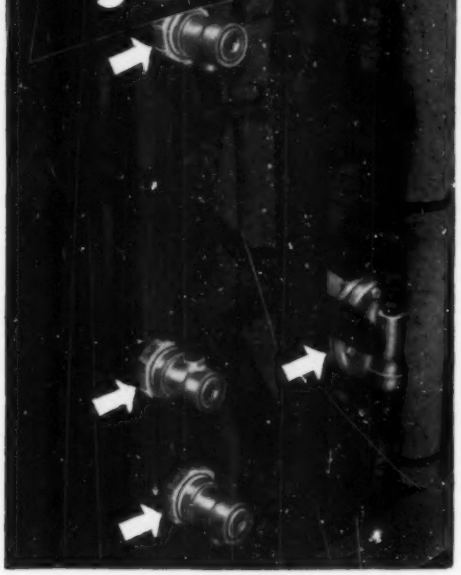
Two 3-pole and one 2-pole contactors are required—each full size, but no transformer, resistor, or reactor, and therefore no extra losses.

This starter lends itself well to motors of standard European connections such as 220/380-volt motors, but standard dual-voltage motors in this country are not designed for star-delta connections. They can, of course, be obtained on special order. The torque curve for star connection will follow the normal delta-connection curve in general shape at $\frac{1}{3}$ the normal values, and cannot be increased. Open transition is mandatory.

Part-Winding Starter

In a standard 220/440-volt, dual-voltage, star-connected motor, nine leads are brought out. These can be connected into two independent 220-volt star windings. If one of these is connected to the 220-volt line, as seen in Fig. 2, we will get a current inrush about 60 percent of the full-

BARCO *Revolving* JOINTS

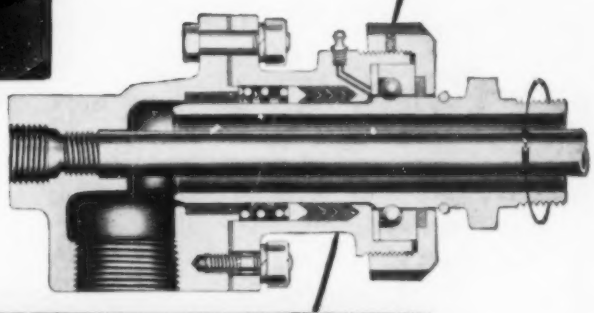


USERS REPORT . . . Many ADVANTAGES!

POWER savings up to 50%... long, leakproof service... very low requirements for maintenance... quick, easy accessibility of parts... better temperature control... ability to withstand vibration and hard usage — these are just a few of the ADVANTAGES reported by the many users of BARCO REVOLVING JOINTS!

AMERICAN FINISHING COMPANY
MEMPHIS, TENN.

User of hundreds of joints on calenders, sanforizers, dry cans and chill rolls, Mr. S. Bernson, Chief Engineer, American Finishing Company writes, "We are well pleased... I hope to have entire plant equipped with Barco joints." Formerly, it was considered exceptional to have 75% of joints leak-free. Today, with the changeover to Barco nearing completion, virtually 100% leak-free service is the rule.



IMPROVED TYPE IBR REVOLVING JOINT

Here is the new, *improved* Type IBR Barco Revolving Joint! It is precision-built in *single flow* and *syphon styles* for handling steam, water, air, oil, gas, or chemicals. Note wide spacing between bearings. Inherent low torque is little affected by pressure, speed, or temperature. Light running action minimizes wear, permits free-floating installation. No adjusting necessary. For the complete story, send today for new Bulletin No. 300. *Worldwide sales and service; ask for recommendations.* BARCO MANUFACTURING CO., 1827 K Winnemac Ave., Chicago 40, Ill. In Canada: The Holden Co., Ltd.

SEND FOR NEW BULLETIN 300

BARCO

THE ONLY TRULY COMPLETE LINE OF FLEXIBLE, SWIVEL, SWING AND REVOLVING JOINTS

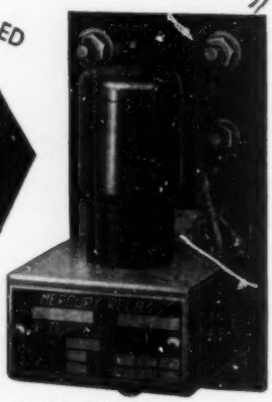
FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

4 STAR TIMER

★ No false contacts
★ No chatter
★ Quiet in operation
★ Eliminates double contacting or breaking of circuit

HYDROGEN PACKED

Durakool
STEEL MERCURY TIMERS



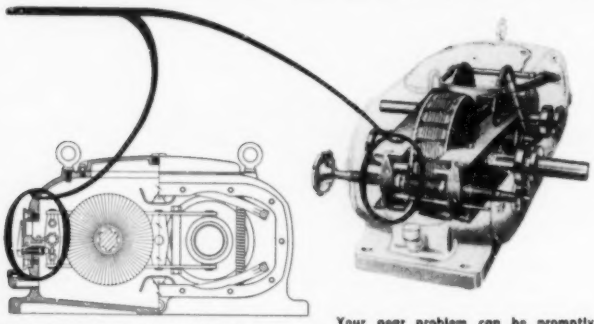
The steel-clad "fixed time" Durakool timer-relay operates in "sealed in" hydrogen under pressure, with mercury to mercury contacts. Timing is tamperproof. Non-breakable and built for millions of contacts. Fixed time delays available from 1/6 to 20 seconds, either normally open or normally closed action.

See Telephone Directory for Local Distributor or write Durakool, Inc. Elkhart, Indiana

Send for Bulletin 800

Mass. Gears

Applied in P. I. V. Variable Speed Drive



Speed changes on the LINK-BELT P.I.V. Variable Speed Drive are shown by means of a rack and pinion, furnished by "Mass Gear," which connects directly to speed setting indicator. Close speed selection, resetting and readings are assured by the accuracy of these gears.

Your gear problem can be promptly and effectively handled by consulting Massachusetts Gear & Tool Co., Woburn, Mass. Write for free illustrated literature.

Massachusetts Gear & Tool Co.

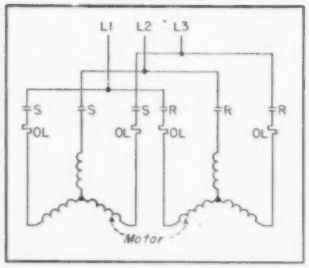


FIG. 2—Part-Winding Starter.

winding inrush producing approximately 50 percent of the full-winding starting torque. If the friction load and inertia are light enough, the motor will accelerate to nearly full speed. When the second winding is connected to the line, there will be a greatly reduced current inrush. Thus, the initial inrush would be the maximum current.

If the load is high enough to prevent rotation, or to drag out acceleration for more than a few seconds, then the second winding must be connected—after a time delay. This will produce a second large inrush peak and increase the torque to normal. If the motor has not started at all, the locked rotor current then will be the same as if strated on full winding, but such a characteristic still should be acceptable where increment starting is permitted. Two contactors, each rated ½ the normal horsepower and each with its own overload relay, are used for the two parts of the windings, together with a time relay. The torque would be on a curve approximately 50 percent of the normal curve.

The leads brought out of a standard, dual-voltage, delta-connected motor can be used if one of the contactors is made full horsepower, but it is not ordinarily suitable for connecting into two independent part windings. However, six leads for part windings easily can be brought out if requested on the order.

Single-voltage motors and motors for 440/550-volt service must be ordered specially for part-winding starting. The two parts of the winding usually are in a 1/1 ratio, but other ratios can be used, depending on how the motor coils can be connected.

Fatigue Strength of Steel At Low Temperature

Abstracted from an article of the same title in *Engineering* Sept. 15, 1950.

WITH LOWER TEMPERATURES, both the tensile strength and fatigue

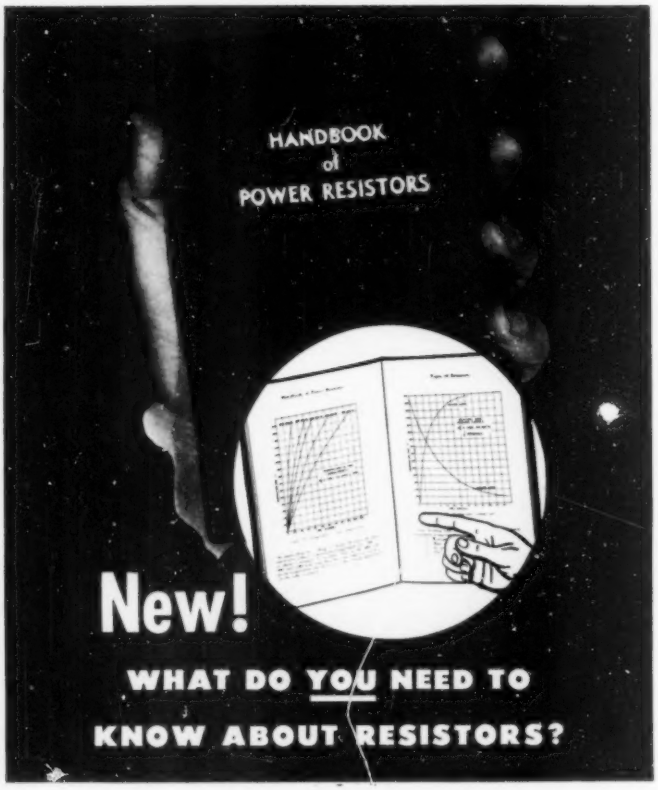
strength of steels increase. However, there is conflicting evidence on some points, for example, the effect of temperature on the ratio of fatigue limit to tensile strength, and on the notch-sensitivity between tensile and fatigue tests. Thus, out of nine cases quoted by Major Teed[1] from published results of tests at room temperature, at —40 and —78C, the ratio of fatigue limit to tensile strength decreased at the lower temperature in four cases, increased in two and remained about the same in the other three. Similarly, there is conflicting evidence about the effect of a notch. According to M. Hempel and H. Luce[2] the ratio of the fatigue limit of an unnotched specimen to that of a notched specimen increases with a drop in temperature. W. D. Boone and H. B. Wishart[3] have found that notched specimen show a more rapid rise in fatigue limit, so that the ratio falls. This discrepancy may be due to different test conditions.

Both the outstanding questions referred to above have been studied by A. Pomp and M. Hempel[4] in a comprehensive investigation of nineteen heat-treated low-alloy steels, four of which were castings. These were tested in various conditions of heat-treatment at +20 and —78C. Tensile, impact and hardness tests were made at each temperature as well as fatigue tests on both notched and unnotched specimens. The form of the notch was the same as that used by Hempel and Luce[2] (60 deg V, root radius 0.1mm, 0.5mm deep, in a test piece 8mm diameter).

With the unnotched specimens the endurance limit (5 million reversals) increased at the low temperature to about the same relative extent as did the corresponding tensile strength. For wrought steels, the general average of the ratio of fatigue limit to tensile strength was 0.458 at +20 and 0.459 at —78C. For castings, this ratio was lower (0.25 to 0.33), but again was the same, within 0.02, at both temperatures. Another point of interest was the value of the ratio of tensile strength to Brinell hardness number over this temperature range. The average values (for tensile strength in tons per square inch) were 0.215 and 0.220, showing that very nearly the same relationship holds for tests at —78C as at room temperature.

For the specimens with a circumferential V-notch, the endurance curves at the two temperatures were, with few exceptions, almost identical. In the exceptional cases (all in the higher alloy range) the endurance limit of the notched specimen was only 1¼ to

NOW
...a BRASS
TRIPLE-LOK
NOW
TRIPLE-LOK
the "Industry Standard" tube fitting is made in steel, stainless steel, aluminum alloy and brass.
BY THE WORLD'S LARGEST
MANUFACTURER OF LEAKPROOF TUBE FITTINGS.
precision-made to be leakproof under even the severest operating conditions.
holds leakproof beyond tube bursting pressures.
3-piece design — remains leakproof after repeated reassembly.
accomodates full range of standard tube wall thicknesses.
shape bodies machined from forgings, other parts from bar stock.
meets ALL industry standards for tube fittings.
made in wide range of shapes and sizes.
STOCKED BY AUTHORIZED DISTRIBUTORS IN PRINCIPAL CITIES ACROSS THE COUNTRY
THE PARKER APPLIANCE COMPANY
17325 EUCLID AVENUE, CLEVELAND 12, OHIO
5827 W. CENTURY BLVD., LOS ANGELES 43, CAL.
Parker
TUBE FITTINGS
VALVES · O-RINGS
The PARKER Appliance Company
Cleveland 12, Ohio
Please send me my free copy of Tube Fittings Catalog 203.
Name
Company
Address
City
State



This new Ward Leonard handbook illuminates a hitherto neglected subject

Somehow—resistors, particularly power resistors, have never been given adequate attention in electrical industry literature.

Now Ward Leonard engineers have filled in the gap with the new *Handbook of Power Resistors*—nearly 200 pages packed with everyday, useful information on resistor types, characteristics, criteria for selection, other helpful data.

Example: For the 99 out of 100 applications where catalog ratings do not apply, derating curves are furnished to help you select the proper resistor for each case.

This handbook is modestly priced at $3.00. Order from WARD LEONARD ELECTRIC CO., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY

Result-Engineered Controls Since 1892

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

2½ tons per square inch higher at the lower temperature. The ratio of endurance limit of the unnotched to that of the notched specimens was, on the average, about 3.0 for the wrought steels and about 2.0 for the castings. It was highest (4 to 5) for alloy steels in the condition of highest tensile strength. By comparison of the endurance curves, it was shown that this ratio (the notch coefficient) increased with the number of reversals. For static tensile tests it was about 0.8 and it increased to a maximum value of 2.5 to 4.5 according to the material and its tensile strength. The notched coefficient tended to increase at the low temperature, but the increase was small averaging about 6 percent.

The general trend of Pomp and Hempel's results may be expressed in the statement that (1) the ratio of fatigue limit to tensile strength at 20 and − 78C is constant for a given steel; and (2) the ratio of endurance limit of an unnotched to that of notched specimens at a given temperature increases with an increasing number of stress reversals and suffers a further increase by lowering the temperature. This further increase is small at −78C, but according to Hempel and Luce[2] may be considerably greater at liquid air temperatures.

References:

1. "The Properties of Metallic Materials at Low Temperatures," London: Chapman and Hall, Ltd. Pages 77-78.
2. Mitt. K. W. Inst. Eisenforschung, 1941, Vol. 23, page 53.
3. Proc. Am. Soc. Testing Materials, 1935, Vol. 35, page 147.
4. Archiv für das Eisenhüttenwesen, 1950, Vol. 21, page 53.

Is Own Product Research A Current Fixed Expense?

By David S. Moffitt, Accounting Staff, Connecticut Hard Rubber Company, New Haven, Conn. Republished with permission from the June 1951 number of the N.A.C.A. Bulletin, published by the National Association of Cost Accountants.

A QUICK, CLEAR CHARACTERIZATION for accounting purposes of management-sponsored product research and development programs in manufacturing companies is given in this article. The author acknowledges at the start that the matter of when and where to charge costs in this area is not one in which general agreement has been reached.

World War II gave great impetus to industrial research and development work, particularly among smaller companies. For many years this work, because of the expense involved, had been carried out almost exclusively by

larger firms. However, the military requirements of the war made it necessary for nearly every company to engage in development programs in its own and allied fields. The success of these programs in companies which had not previously conducted development work on their own, convinced many of the value of retaining such programs as part of regular operations in the reconversion period and afterward.

Alternatives in Accounting Treatment of Research

From an accounting standpoint, research and development costs during the war could be applied to a specific contract or subcontract. After the war, considerable difference of opinion arose among accountants who had not handled the problem in peace-time, as to the best disposition of research and development costs. Most of the confusion arose from the fact that research and development costs fall into a "no man's land," not specifically covered by generally-accepted accounting principles or, more exactly, covered by several conflicting principles. Hence, the accountant can handle them "correctly" in several completely different ways, depending on his own philosophy.

With the increase in the number of firms carrying on their own research and development programs and with budgets for these programs running as high as 20 percent of sales in some instances, it seems to the writer that some general agreement should be reached by accountants as to the disposition of research and development costs, in order that management and stockholders may better understand and appreciate this phase of business activity. Although such work may again have frequent application to military needs and related contracts, the broader question should be resolved.

The two basic ways of handling research and development costs are as current charges or as deferred or capitalized items. Whether charged off currently as in the first case or over a period of time as in the second, final disposition may be made to:

1. A customer's order,
2. General overhead,
3. Selling expense,
4. Product overhead,
5. Profit and loss as a separate item.

To date the method used has commonly varied among companies in the same industry.

Product Research Level Fixed By Management

In discussing the proper charging

and saves customer both space and money

An ice cream freezer manufacturer* was perfectly content with the across-the-line starters used in his equipment.

But we got the idea of saving him some room and dollars by substituting Ward Leonard heavy-duty midget *relays.*

It's a really rugged relay, and certain types are Underwriters' listed as motor controllers. Months of testing proved that a standard Ward Leonard relay with just slight changes would do the job of the heavier starter.

It's another case of Ward Leonard "Result-Engineering" Write us for Bulletin 105 on the heavy-duty midget relay, or for *any* control problem, write WARD LEONARD ELECTRIC CO. 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

***Sweden Freezer Manufacturing Company, Seattle, Washington.**

WARD LEONARD ELECTRIC COMPANY

Result-Engineered Controls Since 1892

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

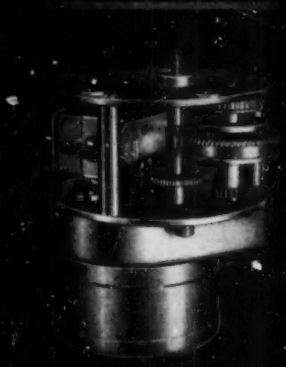
precision built...

Cramer

timing motors

TYPE SX SYNCHRONOUS MOTOR

A permanent magnet type motor producing an exceptionally high torque, the Cramer Type SX Synchronous Motor is widely used with timing devices, recording instruments, communications equipment and for many other applications throughout the instrument and control fields requiring a constant speed at a given frequency. Self-starting operates at synchronous speed only. Compact . . . precision built . . . available with output speeds from 60 R P M to 1 24 R P H.



TYPES SCS & SCR CLUTCH MOTORS

Designed to meet the needs of many timing, recording, indicating, and switching applications where an accurate reset operation is essential, Cramer Clutch Motors combine the Type SX Motor and a differential gear drive. Two basic types . . . Type SCS equipped with direct-acting clutch . . . Type SCR with reverse-acting clutch . . . each available in a wide range of speeds.

Cramer motors are also available as Reversible and Chart Drive Types. Write for complete information.

THE R. W. CRAMER CO., INC.

BOX 7, CENTERBROOK, CONN.

Builders of dependable timing devices for more than 25 years.

INTERVAL TIMERS • TIME DELAY RELAYS • RESET TIMERS • CYCLE TIMERS
PULSE TIMERS • RUNNING TIME METERS • PERCENTAGE TIMERS

of research and development costs, it is well to note that they have become fixed or quasifixed charges in most firms and do not vary appreciably in relation to changed production. This has come about in several ways. First, management decision to appropriate sums for development work is usually arrived at in line with long-term company policy. This policy is framed for the purpose of maintaining the company's competitive position in industry and for supporting the growth of the business. Therefore, appropriation of funds is made in most instances before it is known specifically to which individual projects the funds will be allocated.

In the second place, research and development departments are staffed with highly-skilled men, trained in the intricacies of the particular field in which the company is engaged. Companies are extremely reluctant to release any of these men, even in extreme internal economy drives, because of the cost of finding, hiring and training them and because upon release they (most probably) will find their way into a competitor's employment, with consequent degradation of the competitive situation.

Thus, if an approach to the disposition of research and development costs is made by studying the basic reasons for which such costs are incurred and the manner in which funds are appropriated to cover them (rather than a study of results achieved by various portions of such expenditures), the conclusion is easily reached that these costs are fixed or quasi-fixed charges and should be written off currently. This point of view is certainly the most conservative from an accounting standpoint. From an operational standpoint, as has been noted, it truly reflects research policy determination and the fact that research and development expenses tend to become fixed. The fact that the results of research and development are unpredictable, supports this viewpoint. It seems unreasonable to capitalize the costs of a project when the chances are that the only result will be a nicely bound report with little or no commercial value.

Product Research Chargeable as General Overhead

If we are correct so far, it would seem that research and development costs—besides being fixed costs—are policy costs and should be included in general overhead or, more informatively, as a separate item of the same character. This may be difficult for many industrial accountants to understand because, with modern ac-

ANCHOR

Assembled Hydraulic Hose Units

Tailor-made to Keep Your Costs Down–Performance Up

Factory-assembled to your specifications—save you time and money, give you a better job

For extra protection against leaks and blow-offs at high pressures use factory-applied Anchor Ductile Sleeve Hose Couplings with their exclusive patented grip.

Anchor adapter unions save assembly time and piping expense. Use them and other styles of related Anchor fittings to simplify your piping problems.

FOR longer service life — you design your machines with great care and manufacture them to rigid tolerances.

But the job is not done until you invest the same care in selecting and specifying hose units. After all, the performance of your machines is dependent upon them.

That's why Anchor offers factory-assembled hose units. They are made to exact lengths in accordance with your drawings. And the couplings are factory-applied by experts with specially designed machines to give you leakproof dependability and extra safety. They cost less in the long run — because they give better service, keep your customers satisfied.

Shown here is a rayon two-braid hose-assembly designed for medium and low pressures. Made from specially selected synthetic rubber, it has excellent flexibility. This same unit is also available in a single-wire braid hose.

For high pressures Anchor Ductile-sleeve hose-couplings are your best choice.

Take out performance insurance. Reduce assembly time and costs in your plant and in the field. Equip your machines with Anchor factory-assembled hose units.

Send for complete information on Anchor assembled hose units.

Clip coupon to company letter head — and mail TODAY!

ANCHOR COUPLING CO. INC. Dept. PE-91
Libertyville, Illinois

I like the dependability, the safety, and the time-and-money-saving features of Anchor Assembled Hose Units. Please send me Bulletin No. 495.

Name ..... Position .....

Company .....

Company Address .....

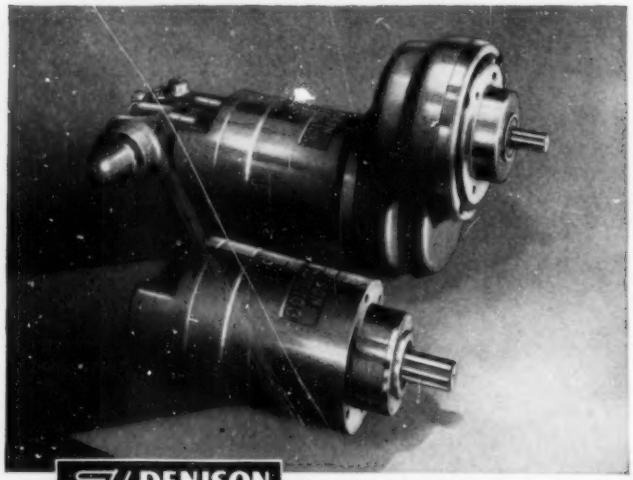
City ..... (.....) State .....

9-8

ANCHOR COUPLING CO. INC.
Factory: Libertyville, Illinois • Branch: Detroit, Michigan

SHOCKPROOF ROTARY POWER

stands up under constant stop-and-go action



DENISON Hydraulics **Denison Fluid Motors**

Are Built for Tough Rotary Drive Needs

Do you need *tough* rotary drives that laugh off the *continuous abuse* of sudden, jolting starts . . . lightning acceleration . . . split-second stops . . . powerful braking action . . . instant reversals, and other punishment? Denison Fluid Motors meet these demands with smooth-working ease and efficiency. They've proved their long-wearing ruggedness on a wide range of motor-killing jobs. (And of course, this makes them even more dependable for hundreds of run-of-mine needs.)

These compact, axial piston motors are self-lubricated in a continuous bath of the same oil that gives them their efficient, shockproof driving power. Their improved design features fewer parts. Space-saving, close-coupled assembly simplifies application, and cuts maintenance costs.

Denison Fluid Motors are built in 3hp to 160hp sizes, for operating pressures to 5000 psi. Torque ratings range to 5580 inch-pounds. Operating speeds to 3000 rpm. They operate with full efficiency in any position. Gear reduction attachments (as shown on top unit in photo above) are available for smaller models. A choice of face, flange or foot mountings is also offered. Drop the word and we'll send you full information on Denison Fluid Motors that fit your needs.

The DENISON Engineering Co., 1157 Dublin Rd., Columbus 16, Ohio

DENISON FLUID MOTORS

counting tools, it is very easy to segregate development costs applicable to individual orders, products or sales propositions. There is a strong impulse to believe that every cost which can be separated and distributed to a particular item should be applied to that item. It may very well be that this easy distribution has caused much of the confusion connected with the question of disposition of research and development costs.

An example will help here. Let it be assumed that a company has successfully and at great expense developed a new product which is expected to provide a large proportion of future sales. Some accountants would capitalize the expense and charge it off against the product in future years. However, this would give a distorted profit picture during the years of development by eliminating a portion of the fixed research and development expense. It would also distort the inventory picture in future years by adding to inventory, costs which are in excess of the out-of-the-pocket costs necessary to produce the new item.

On the other hand, if the expense of developing the new product is written off currently as an item of general overhead or a separate profit and loss item, the profit and loss statement for the development period will show the fixed cost of the development work. Future inventories will show true costs of production. And if, as anticipated, sales of the new product turn out to be a large proportion of total sales, they can be expected to provide gross profit to cover their share of the current development expense in the years in which such sales take place.

Similarly, the costs of developing a special process or piece of machinery, if capitalized and distributed over the production in future years, will hide the fact that those costs have to be met during the period of development, whether or not the program is successful. It would seem, therefore, more valuable to management and owners to have these costs reported as a separate, current item on the income statement.

Research Sold in Contracts or Purchased in Patents

Research and development work for outsiders on a contract basis falls into a different category. The costs incurred are not a result of company policy and are not fixed. The reporting of these costs of goods (or services) sold is certainly justified. If the present mobilization trend continues, more development work will

be carried out on this basis, as companies shift from working on their own problems to those of the military.

Then, too, the purchase of patents and completed developments should be handled differently from research and development carried on as dictated by company policy. In the case of such purchases, the actual value and life of the expenditure to the company can be determined in advance. The cost is non-recurring and not fixed. These purchases can rightly be capitalized as permanent assets.

A Comparison With Advertising Costs

In this paper, the writer has outlined the case for considering research and development program costs as current, fixed costs, with the thought that this basis might prove acceptable to a majority of accountants on examination of the reasoning behind it. Under this reasoning, research and development costs are regarded from the viewpoint of their incurrence rather than from the developmental results obtained. Charging them off currently as a separate item is a proper reflection of this viewpoint. The method is not widely different from that used in handling advertising costs. The ultimate purpose in both cases is to provide management and stockholders with facts truly picturing the operation of the company.

Shotpeening As A Factor In The Design of Gears

Abstracted from Mechanical Engineering, July 1951. Article by John C. Straub, American Wheelabrator and Equipment Corporation.

SHOTPEENING is an important consideration in the design of gears which are required to operate at high loads or high speeds or both, particularly in cases where weight and size are at a premium.

This paper concerns itself primarily with the design of the gear teeth themselves, especially on spur and helical gears. The author groups gear teeth failures into three classes as follows: (1) Tooth breakage; considered due to bending stress and commonly known as a fatigue type failure. (2) Pitting; characterized by pits or small craters in the contacting surface of the tooth, and also a fatigue type failure. (3) Scoring; evidenced by a decided roughness on the working surface. This condition is caused by high compressive stresses in combination with sliding of the surfaces.

Since a simple, general mathemat-

FASTER ROTARY FEEDING

speeds loading on production operations

Denison Index Tables with DENISON HydrOILics

Fluid Motor Drive Adaptable to Many Machines

Driving the Denison Index Table shown above is a typical job for the tough, shockproof rotary power of Denison Fluid Motors, described on the opposite page. Available for either six or twelve-station indexing, these tables operate at speeds up to 70 indexes per minute. At top speeds, the motors have *less than one second* to leap from a dead stop to full speed, rotate the table 30 or 60 degrees, and return to a full stop. And they keep it up day after day, month after month.

A four-way gain is realized when machines are equipped with Denison Index Table Feeds. 1. Faster loading permits higher production speeds. 2. Safety is increased because operator's hands are never within reach of the moving machinery. 3. Operators can load parts while machine operation is being performed. 4. There's less fatigue because operators have maximum time for parts-loading without risk of injury.

The table is rotated and indexed by a Geneva arbor drive, actuated by the variable speed Fluid Motor. Table speeds are variable from 10 to 70 indexes per minute. Positive interlock between the operation of the table and the production machine can be provided. A cam track within the table dial permits a variety of automatic ejection devices. Skip-station controls are also available, where tooling is not desired at all index stations. Write for full details on Denison HydrOILic Index Tables.

The DENISON Engineering Co., 1157 Dublin Rd., Columbus 16, Ohio

DENISON INDEX TABLES

AN approved (3303-1)

R-B-M

ELECTRONIC AND COMMUNICATION RELAYS

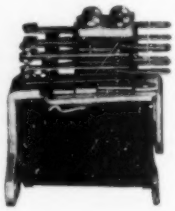
Now Hermetically Sealed

HUNDREDS of thousands of R-B-M telephone type relays saw Government service in World War II. Now most of these relays are available in hermetically sealed enclosures designed to meet AN specifications.

R-B-M hermetically sealed telephone type relays are available in contact forms up to and including 4-pole, double throw, 3 ampere, 28 Volts D. C. construction. Also 10 ampere rating up to and including 2-pole double throw at 28 Volts D.C. All relays available with approved AN plug connector, or with solder connections.

Engineers! What is YOUR hermetically sealed relay requirement? R-B-M is developing new and smaller relays to meet Armed Services requirements. Perhaps one of these will solve your problems. Write giving complete relay specifications, application, quantity and AN specifications applying. Address Dept. C-9.

AN approved (3304-1)



R-B-M Production and Engineering facilities in two plants, located in different states, (over a quarter million square feet), can assist you in the development and production of special electro-magnetic devices for Armed Services application.

RBM

R-B-M DIVISION
ESSEX WIRE CORP.
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

ical solution of bending stresses in gears is impossible due to undeterminable variables, the author resorted to testing of a large number of gears of different design and load carrying capacity under working conditions.

Shotpeening is a recognized effective means of increasing fatigue strength. Its effectiveness in overcoming fatigue failures in existing designs is well known. But its advantages in designing for fatigue strength and greater utilization of material are often overlooked.

A fatigue chart of carburized automotive type spur and helical gears, shotpeened and non-shotpeened shows the added strength obtainable by the former. At a calculated strength of 71,000 psi on non-peened gears an average life of 800,000 cycles is obtained. For the same average life, the allowable stress for shotpeened gears is 88,000 psi—an increase of more than 24 percent.

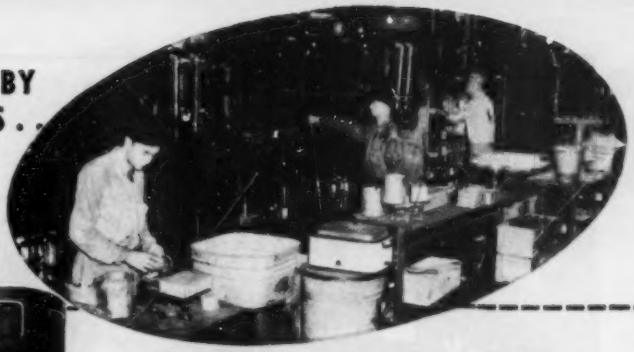
From the standpoint of increase in life at a given calculated stress, the chart shows, for example, that at a calculated stress of 80,000 psi the average life of non-peened gears is 300,000 cycles, and for shotpeened gears, >,000,000 cycles, or an increase of 1,000 percent.

Scoring resistance is calculated in this paper according to the method developed by the author under the direction of J. O. Almen of General Motors Corporation. It consists of the calculation of the product PVT, where P equals the maximum compressive stress, V, the sliding velocity and T, the distance in the plane of rotation from the pitch point to the selected point. All the test data accumulated were on fully hardened spur gears, lubricated with mineral oil. In general, those gears with a PVT factor in excess of 1,500,000 failed by scoring while those with a PVT less than this did not. With extreme pressure lubricants a PVT in excess of 1,500,000 can be used.

A study of design considerations from the standpoint of both bending strength and scoring resistance reveals a conflict between factors desirable to each. In order to obtain satisfactory operation with minimum weight, it may be necessary to compromise between bending strength and scoring resistance. An advantage can be taken by designing the gears with a finer pitch in favor of scoring resistance. The resultant decreased bending strength can be restored by shotpeening. By this reasoning shotpeening can be used directly to increase bending strength, or indirectly, by proper design consideration, to increase scoring resistance.

SMALL PLASTIC PARTS BY THE THOUSANDS . .

BIG PLASTIC PARTS BY THE HUNDREDS . . .



Aico Compression Molding offers balanced production of a wide variety of plastic parts

Division of responsibility among several suppliers is avoided when you use Aico's complete compression molding facilities to maintain a *balanced* supply of parts to fit your production schedule.

At Aico, 83 compression molding presses . . . ranging in size from 20 to 2000 tons . . . are at your service. The latest preheating equipment is used to provide scientific control of material and to achieve increased production efficiency . . . both of which result in lower unit costs.

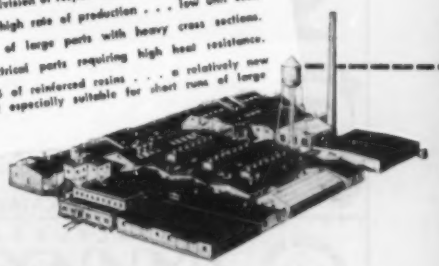
For parts of intricate shape . . . parts with delicate inserts . . . or parts with close tolerances . . . Transfer Molding is available in Aico's Compression Molding Department.

Take advantage of the convenience and economy of working with a single supplier. Let an Aico engineer give you a straight forward recommendation on the *proper* use of plastics. There's no obligation . . . we welcome the opportunity to be of service. Drop us a line today.

AMERICAN INSULATOR CORPORATION
New Freedom, Pa.

Aico's Complete Plastic Molding Service Includes:

ENGINEERING COUNSEL on proper molding methods and materials.
MOLD BUILDING to avoid division of responsibility.
INJECTION MOLDING for high rate of production . . . low unit cost.
COMPRESSION MOLDING of large parts with heavy cross sections.
COLD MOLDING of electrical parts requiring high heat resistance.
LOW-PRESSURE MOLDING of reinforced resins . . . a relatively new low-pressure development especially suitable for short runs of large lightweight pieces.



MANY THINGS ARE BETTER BECAUSE OF

PRECISION MOLDED

Thinking of Stainless?
Think of ALLMETAL for the finest in STAINLESS STEEL FASTENERS
MADE RIGHT —
By specialists in stainless steel since 1929.
PRICED RIGHT —
Because ALLMETAL uses modern equipment—including cold-heading machines—devoted solely to stainless.
RIGHT COMBINATION
For solving fastening problems quickly, economically.
Allmetal has the fasteners you want. Stock items, including Government and "AN" specs, shipped immediately. Prompt delivery on various types of Phillips Recessed Head screws and specials. Switch to Allmetal Stainless Fasteners when you switch to Stainless!
Use our "Rush Order" direct wire service — Send telegrams to "Allmetal Screw Products — WUX — New York." — that's all —
WRITE FOR CATALOG 49F
MANUFACTURERS SINCE 1929
ALLMETAL
Screw Products Co., Inc.
33 GREENE STREET, NEW YORK 13, N. Y.

Sans, Souci

Ad Libbing by the Editor

In June I described the failure of a rolling mill shaft. A hollow shaft had been substituted for a solid shaft and the failure was attributed to the relatively high rigidity of the hollow shaft. It is obvious from the reading of the item that it was written Sans Souci, in other words, without care. Henry C. Gray of the Falk Corporation called my attention to the fact that in the presentation, "Something is lacking. Something not in the picture caused the failure of the hollow shaft designed by the bright young engineer."

As pointed out by Mr. Gray, two questions are involved, namely, strength and resilience. But the data wasn't sufficiently specific concerning proportions of the hollow shaft. According to Mr. Gray, for two such shafts of the same cross-sectional area with the outside diameter of the hollow shaft being twice its inside diameter, the torsional strength of the hollow shaft is 1.44 times the torsional strength of the solid shaft. And, the torsional resilience of the hollow shaft is 1.25 times of the solid shaft. On the basis of those figures, the hollow shaft would be superior both with reference to torsional strength and the ability to absorb energy, which is correct.

The above picture changes considerably when the hollow shaft and the solid shaft are compared on the basis of equal torsional strength. Mr. Gray is one hundred percent correct in his deductions and also in his statement that there was something lacking in the original presentation. The solid shaft is stronger against impact loads only when the outside diameter of the hollow shaft is relatively large and its section modulus is the same as that of the solid shaft. The next time I will put a little more Souci into anything involving design.

All this leads me to the thought that it is often expensive to bull-headedly insist that white is black. When a mistake is obvious or when there are errors of omission it is always best to keep an open mind, admit the error, and get on the job to correct it.

A company that operated a large refrigerated warehouse bought a new compressor. Immediately their power bills jumped all out of reason. Because a new motor and new electric meters had also been installed,

R.F.D. Reliable Food Delivery

The enormous food production of rural America is made possible by farm machinery—machinery that multiplies man power and old fashioned horsepower many, many times.

Many makers of farm machinery use "Double Diamond" Gears. This is particularly true of tractors. Making spiral bevels for leading tractor manufacturers is one of our biggest and most satisfying jobs. Big because of the volume of work entrusted to us. Satisfying because it contributes in small part to the success of the nation's mightiest enterprise—the American farm.

IMPORTANT NOTICE TO PRESENT AND FUTURE CUSTOMERS

During the present abnormal period Automotive Gear Works believes its first loyalties are due its present customers, many of whom are directly or indirectly in defense work. For that reason, every effort will be made to first satisfy the growing requirements of those companies who are already users of "Double Diamond" Gears. Where facilities or materials permit, the requirements of prospective customers will receive careful attention, and technical assistance will continue to be made available for the solution of gear problems regardless of whether or not we are now in a position to build the gears recommended.

DOUBLE DIAMOND TRADE MARK GEARS

AUTOMOTIVE GEAR WORKS

RICHMOND, INDIANA

FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS

Reg. U. S. Pat. Off.

HYPOID BEVEL · SPIRAL BEVEL · FLYWHEEL GEAR · ZEROL BEVEL · STRAIGHT BEVEL · STRAIGHT SPUR · HELICAL SPUR · SPLINE SHAFT

NO, SIR!
The Seal Won't Blow!

METALLIC-BACKED neoprene seals are used in this famous bearing — and they are engineered to *stay put.* They can't blow.

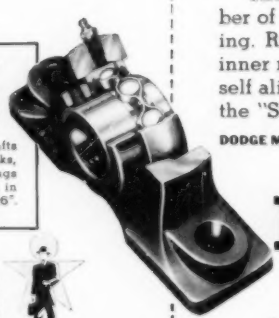
Your lubricant stays in; dust and dirt stay out; the result is years and years of trouble-free performance.

The "SC" Bearing is a service-proved member of the Dodge 30,000 hour line. Modern styling. Rugged one-piece cast-iron housing. Long inner race. Radial and thrust load capacity. Fully self aligning. *WRITE* for complete information on the "SC" Bearing in the Dodge catalog.

DODGE MANUFACTURING CORPORATION, 1200 Union St., Mishawaka, Ind.

DODGE TYPE "SC" BALL BEARING PILLOW BLOCK

Precision built bearing for small shafts and moderate loads. Pillow blocks, flange bearings and hanger bearings available from distributors' stocks in shaft sizes ranging from 3/4" to 2-7/16".



CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained, he can give you valuable assistance on new, cost saving methods. Look for his name under "Power Transmission Equipment" in your classified telephone book.

DODGE

of Mishawaka, Ind.

FIRST IN POWER TRANSMISSION MACHINERY

NAME PLATES

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, CHICAGO THRIFT-ETCHING CORPORATION, 1555 SHEFFIELD AVENUE, CHICAGO 22, ILLINOIS

they immediately suspected something wrong on the electrical end of the equipment. So they complained to the power company.

The power company sent a couple of engineers down to check the meters and go over the whole installation. Their report was, that there was absolutely nothing wrong with any of the electrical equipment. They advised the warehouse people to call in an engineer to go over the compressor. Naturally, the warehouse people called upon the vendor. The vendor sent a salesman out who walked around the machine and decided that there couldn't be anything wrong with the compressor. The warehouse people became highly incensed with the treatment they had gotten and called upon a consulting engineer to make a test. He did and the indicator cards he took on the compressor clearly showed something wrong with the suction valves. Either they were broken or did not seat properly.

Sample indicator cards were sent to the compressor manufacturer along with a copy of the report of the consulting engineer. This brought the sales manager and a few more of the sales boys from the compressor company. These fellows gave a high pressure sales talk to prove that there couldn't be anything wrong with the compressor, that the consulting engineer didn't know his business and even made veiled insinuations that maybe the power people were trying to cheat.

The general manager of the warehouse wasn't stupid. In fact, he was all ready for that kind of an attitude and he had his mechanics there and everything was ready to take off the cylinder head to expose the suction valves. When the head came off, one of the suction valves dropped out in two pieces. It was broken. What happened after that can be left to the imagination. It would have been far better had the salesmen from the compressor manufacturing company taken a constructive and sympathetic attitude rather than trying high pressure sales stunts. They lost a good customer.

Some years later I heard of a somewhat similar situation in a silk mill which had installed a turbo generator. The turbine was consuming about thirty percent more steam than the guaranteed consumption. The terms of the sale called for a test at the option of the purchaser. The turbine manufacturer sent an engineer to represent them. A consulting engineer, selected by both parties, ran the test. The steam consumption proved to be

can old age "cripple" your important drawings?

Not if you put them on Arkwright Tracing Cloth. Arkwright Cloth is the best insurance you can get that your drawings will never become brittle or opaque with age — never get paper-frayed around the edges to spoil your work.

Arkwright's extra quality shows right from the start. You can re-ink clean, razor-sharp lines on Arkwright Tracing Cloth over the heaviest erasures without feathering or "blobbing". And you can get clean, clear blueprints — if you need to — for years and years to come.

All good reasons for you to remember: if a drawing is worth saving, put it on Arkwright Tracing Cloth. Write for samples now to Arkwright Finishing Co., Industrial Trust Bldg., Providence, R. I.

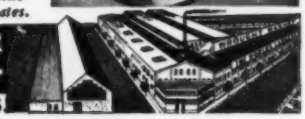
ARKWRIGHT
Tracing Cloths
AMERICA'S STANDARD FOR OVER 30 YEARS

Since 1887

MILWAUKEE WROT WASHERS

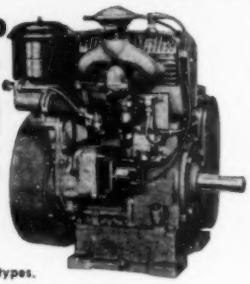
Better WASHERS ... Competitively Priced

Large volume production, the most advanced methods and facilities, plus more than 60 years of continuous experience in the manufacture of Washers, are factors that enable us to offer you top quality washers and stampings at competitive costs. Over 22,000 sets of dies for making Washers of every type (Standard and Special), from every type of material, for every purpose, in any finish. STAMPINGS of all descriptions; Blanking, Forming, Drawing. *Submit your blueprints and quantity requirements for estimates.*



WROUGHT WASHER MANUFACTURING CO.
The World's Largest Producer of Washers
2213 S. BAY ST., MILWAUKEE 7, WIS.

POWER ADVANTAGE in the 7 to 13 hp. Range ... The 2-Cylinder WISCONSIN *Air-Cooled* ENGINES



Here is the POWER ADVANTAGE story of the 2-cylinder Wisconsin Heavy-Duty Air-Cooled Engines, the development of which fills the need for a power linkage between the single-cylinder and four-cylinder types.

1. Dependable air-cooling under all climatic and weather conditions.
2. Self-cleaning tapered roller bearings at both ends of the crankshaft to withstand either side-pull or end-thrust without danger to bearings.
3. Rotary type high tension OUTSIDE Magneto with Impulse Coupling operates as an entirely independent unit that can be serviced or replaced in a few minutes.
4. Maximum torque at usable speeds for equipment that really has to go to work.

CONDENSED SPECIFICATIONS

MODELS		TE	TF
Bore	inches	3	3¼
Stroke	inches	3¼	3¼
Piston Disp. cubic inches		45.9	53.9
Horsepower			
1400 rpm		7.2	8.6
2000 rpm		10	12
2600 rpm		11.2	13.3
Net weight in lbs., Standard engine, side-mount tank		220	220

Our engineering department will gladly cooperate with you in adapting Wisconsin Engines to your requirements. Write for detailed data and name of the nearest Wisconsin distributor.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

about thirty percent high. The turbine manufacturer was dissatisfied with the test and demanded a rerun. The consulting engineer suggested that it might be well to take off the turbine cover and see if there was anything wrong. This suggestion was not accepted. So a second test, costing about $500.00, was run. The second test likewise showed excessive steam consumption.

The cover of the turbine casing was then taken off and it was quickly discovered that the shaft seals between the stages had been omitted. A telephone call to the plant of the turbine manufacturer brought back the reply the next day that the seals were still in the finished-parts warehouse and for some reason or another had never been installed in the turbine. Here again, the manufacturer would have profited had his representative investigated, at little or no expense, before demanding further tests.

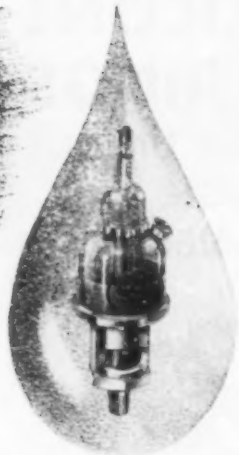
Admittedly, it is a human failing to resist to the utmost the admission of a mistake. But the smart man will admit his mistake before further damage is done. Properly handled mistakes can be profitable and constructive.

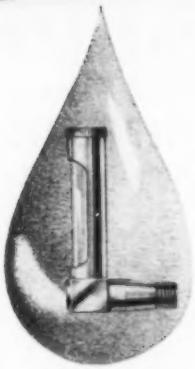
One of my good friends was a college professor in chemistry. He is unusually bright, a tremendously hard worker and never seemed to concern himself as to whether he received equitable compensation. He was not stupid about this matter, but he did do a lot of work for which he received no monetary return.

One day, Shorty, as we all called him, and I were having a discussion. Because we knew each other very well, we could talk frankly. I told him that he would probably still be working there when he became a wheezy old man, plugging away at a college professor's salary and at the same time doing a tremendous amount of research work in the field of paints and varnishes for which he received little or no pay but from which industry profited handsomely. Shorty smiled and said that he had a definite objective, was not concerned over his immediate income, but that undoubtedly the time would come when some manufacturer, most likely a paint manufacturer would offer him a handsome position. In the meantime he would put forth every effort to learn more and more about paint vehicles. He firmly believed that it was impossible to do a job outstandingly well without being rewarded.

It was about five years later when I was talking to a duPont paint research chemist that it dawned on me exactly what Shorty had in mind. Not knowing that Dr. J. S. Long was my long

For Lubricating Devices Call On GITS First!

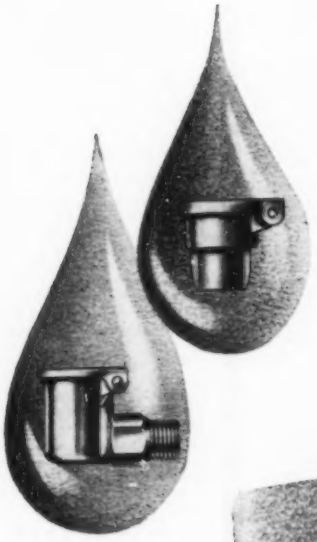




GITS Bros. covers the *entire range* of lubricating devices: Oil Hole Covers, Oil Caps, Grease Cups, Bottle Oilers, Gauges. Gravity-Feed, Wick-Feed, Constant Level, Vibrating Rod styles. Threaded or Drive-type. Elbow or Straight.

GITS Bros. offers the most complete selection of standard styles.

GITS consistent quality in design, materials and machining has made Gits Lubricating Devices the standard for industry for more than 40 years.



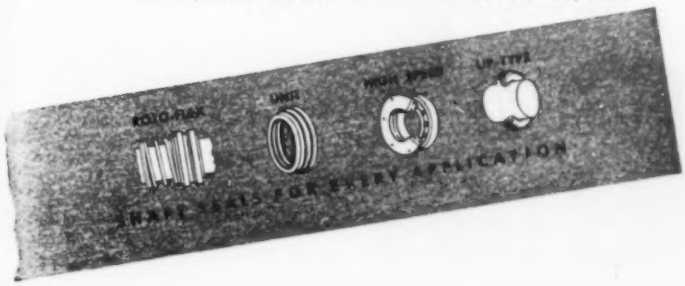
GITS Lubricating Devices are far-famed for solving tough oiling problems at low cost.

GITS Bros. Engineering Staff—true specialists in lubrication engineering—is at your disposal.

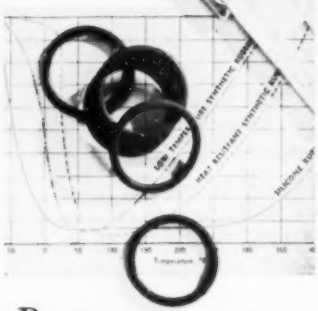
Write today for free illustrated Price Guide Catalog. Use it as your handy reference for lubricating devices.

GITS BROS. MFG. CO.

1838 S. KILBOURN AVE. • CHICAGO 23, ILL.



SILICONE "O" RINGS OFFER UNIQUE DESIGN POSSIBILITIES



Because of the inherent stability of silicone rubber, Arrowhead "O" rings molded of this remarkable new material provide a long-lasting seal under conditions far beyond the limits of ordinary rubbers. For example, they remain flexible at -130° F.; withstand indefinitely, exposure to temperatures of 500° F. and over. They offer excellent resistance to oxidation, to many oils, acids, alkalies and a variety of chemicals. The ideally inert characteristic of these seals is demonstrated by their astonishing resistance to aging, even at abnormally high temperatures. At normal temperatures they last *indefinitely*. For superior performance under severe conditions, consider silicone rubber. Arrowhead's *silicone specialists* will welcome your inquiry.

Write **FOR ENGINEERING DATA**

Free to Engineers – two valuable new publications on silicone rubber and "O" rings. Contain complete technical and descriptive data, including typical applications.

ARROWHEAD RUBBER CO.

Division of National Motor Bearing Co., Inc.

DOWNEY (Los Angeles County) CALIF.

"O" RINGS • SILICONES • AIRTRON DUCTS

time friend, Shorty, the duPont man stated that, "Dr. Long is the country's leading authority on paint vehicles. He heads up the activities of the American Chemical Society in that field and it is too bad that Dr. Long has resigned his college job to become director of research of DeVoe & Raynolds Company, the paint manufacturers." It was not long after that that Dr. J. S. Long became vice president in charge of all of the chemical operations of that company

Now the significant thing about this whole episode is that Shorty had laid out for himself a career. He thought nothing of sacrificing in order to enable him to become one of the country's outstanding authorities in his field. He had the conviction that it would be impossible for him to do all the things he did in furthering the interests of the paint and varnish people and not be recognized. It was not long until he was recognized, and handsomely so.

Too many young men after graduating from college go into a business career and promptly stop learning. That is what the majority of them do and each of those men is just one of a whole big crowd. They often wonder why they don't succeed to top level positions. Little do they realize the penalty for ceasing to learn upon graduation.

Because of a tremendous increase in our fund of knowledge it is today more important than ever before that the college graduate shall continue learning after he graduates. Graduation is but the commencement of a career. What the career shall be is largely determined by the individual.

—G.F.N.

Rare Metal Inspects Aluminum Castings

OXFORD (ENGLAND) — Metal castings of light alloys can now be inspected successfully for dangerous defects through use of gamma rays from a rare $7,000 per oz metal, Thulium, irradiated in an atomic furnace, according to the Atomic Energy Research Establishment, Harwell, England.

When irradiated in an atomic pile, Thulium becomes radioactive and then gives off softly penetrating gamma rays which are of the right intensity for making a full detail radiographic picture of a one-half inch thick aluminum casting. Radiothulium has a useful half-life of over 100 days.

THAT TOUGH INTERCOM PROBLEM NO ONE ELSE CAN LICK...

may be a natural for

WHEELER

Sound Powered

TELEPHONES

- **NO BATTERIES**
- **NO OUTSIDE POWER**
- **NO ELECTRICAL HAZARD**
- **NO MAINTENANCE**

Besides being a practical low cost system for every day intercom services (up to 12 stations), Wheeler Sound Powered equipment is SPECIALLY adapted to meet UNUSUAL needs where added *privacy*, continuity in event of power failure, *almost negligible* electrical currents and freedom from expense of deterioration are factors.

Wide adaptability... ringing or visual call... rugged construction..., special high level units for noisy locations. Write us for full details and recommendations.

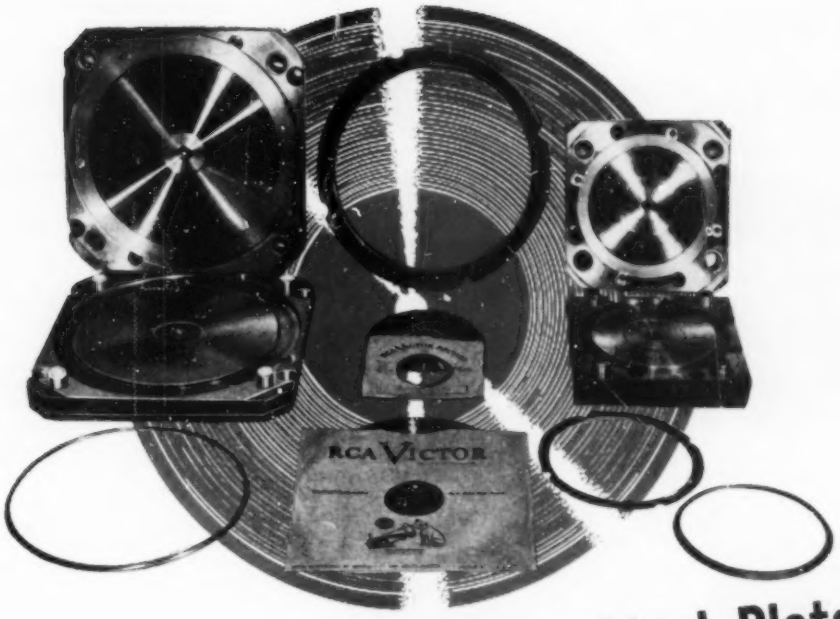
Available through national distributors such as G. E. Supply, Westinghouse Electric Supply, Allied Radio or your independent electrical or electronic jobber.

THE WHEELER INSULATED WIRE CO., Inc.

Division of the Sperry Corp.

1103 EAST AURORA ST.

WATERBURY 20, CONN.



It's SPEED TREAT Steel Plate for *Record* Breaking *Record* Making

For a number of years RCA Victor has been making their phonograph record molds of Speed Treat (x1545) medium carbon open hearth steel plate—one of Holliday's Speed Steels. Both halves of the mold are made in two sections which are brazed together. A water and steam cooling chamber, subjected to 130 p.s.i. pressure, is provided within the two sections. The Speed Treat molds must withstand 3,500 p.s.i. pressure or 80 to 100 tons across the entire mold.

Speed Treat was selected because it brazes easily using silver solder and because of its greater machinability — molds machined complete in 22 to 23 hours. Speed Treat replaced 4130 forged steel. The molds are not heat treated. They operate at temperatures from 260° to 290° F. The flatness tolerance is .001 and the tolerance of parallel dimensions is .002.

Quality of RCA Victor Records is world renowned and record breaking quantities are not uncommon. Time-saving machining schedules and the necessity for a mold steel that "can take it" call for Speed Treat. The supply of Speed Treat is limited, but check with your nearest source. Keep yourself posted on this unusual plate steel.

The Speed Steels are: Speed Case (x1515), Speed Treat (x1545) and Speed Alloy hot rolled alloy steel plate.

STEEL . . . . . Since 1856

W. J. HOLLIDAY & CO.

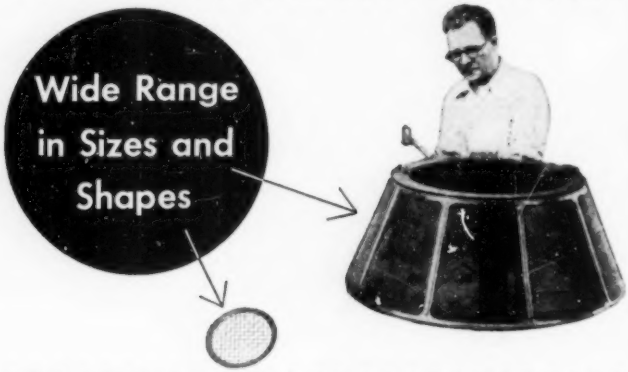
(INC.)

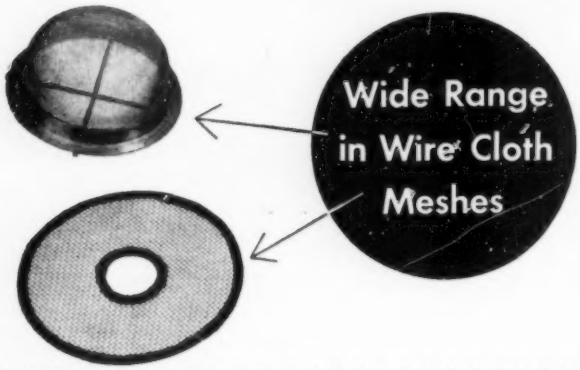
SPEED STEEL PLATE DIV.
120 139th St., Hammond, Ind.
Plants: Hammond and Indianapolis, Indiana

DISTRIBUTED BY

Brown-Wales Co., Boston-Hartford-Lewiston, Me. ▪ Bridgeport Steel Co., Bridgeport, Conn. ▪ Booth, McCarthy & Rogers, Buffalo, N. Y. Harper Iron Co., Akron, Ohio ▪ Grammer, Dempsey & Hudson, Inc., Newark, N. J. ▪ Earle M. Jorgensen Co., Los Angeles-Houston-Oakland-Dallas ▪ Passaic County Steel Service, Inc., Paterson, N. J. ▪ Peckover's Ltd., Halifax-Montreal-Toronto-Winnipeg-Vancouver ▪ Peninsular Steel Co., Detroit, Mich. ▪ Pidgeon-Thomas Iron Co., Memphis, [illegible] ▪ Thomas T. Potts Co., Philadelphia-Baltimore

NEWARK
Fabricated Wire Cloth Parts





We have the facilities and skilled workers to make a great variety of wire cloth parts. We're doing a lot of work along these lines. We do the assembling in our own plant, using our own well known "Newark" Cloth. We bring to this work experience gained by several generations of wire cloth manufacturing and many years experience in fabricating and assembling parts. We'll be glad to quote on your next requirements. If you would like suggestions as to how best make use of wire cloth in the assembling we'll be glad to help. Send us an outline or print of your problem.

NEWARK for ACCURACY

Newark Wire Cloth COMPANY

351 VERONA AVENUE • NEWARK 4, NEW JERSEY

Philadelphia 3, Penna. 1311 Widener Bldg. | San Francisco, Calif. 3100 19th St. | Chicago, Ill. 20 N. Wacker Dr. | New Orleans, La. 520 Maritime Bldg. | Los Angeles, Calif. 1400 So. Alameda St. | Houston, Texas P. O. Box 1970

OUR READERS SAY

Who Checked the Checker?

To the Editor:

We read PRODUCT ENGINEERING thoroughly and keep all copies on file. The information available and its use in reference is very valuable. Because of our high regard for your publication we wish to bring to your attention an article on page 160 of the July 1951 issue. The article is basically very interesting and we might add extremely important. However, we feel that such an article should be carefully checked before publishing. If one of our checkers approved such a drawing with changes indicated we would look for a new checker. There are several errors and I certainly feel that these should be corrected particularly in an article attempting to instruct in the proper procedure of checking.

—B. H. MCCURDY
Hancock Mfg. Co.

Ed—Your letter makes our face turn red. We have no alibi for the errors overlooked by the checker who checked the drawing shown on page 160 of our July number. We simply had too much faith in the accuracy of our contributor's work. The result shows that our faith was not well founded. But it is our fault that the drawing was not checked thoroughly before it was reproduced and published. Unfortunately when errors get into print, they never die.

We are also disappointed in our attempt to use color in this particular drawing. The printer did a poor job in matching the color plate with the black plate. In most of our copies the plate registry is off both horizontally and vertically.

As much as we would like to, it will be economically impossible for us to make new plates of a corrected drawing and reproduce them in a future issue. We will just have to let it stand.

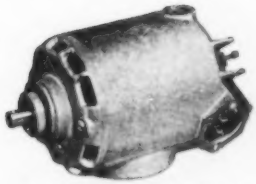
International Conflict on Fluid Flow

To the Editor:

The article "Energy Losses in Hydraulic System" by Nils M. Sverdrup, in PRODUCT ENGINEERING, April 1951 was of extreme interest. The

Universal motor parts for portable electric tools, garage equipment and other industrial devices.

Double shaft extension motor for flap control on small aircraft and other dual uniform control applications.



Having inbuilt control switch and receptacle, this motor is readily adaptable to portable tools and equipment.

Proved PERFORMANCE

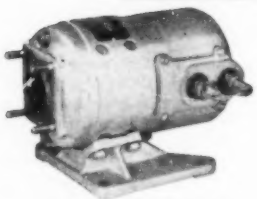
Lamb Electric

SPECIAL APPLICATION
FRACTIONAL HORSEPOWER **MOTORS**

During normal times and emergency times — for the past 36 years — Lamb Electric Motors have had an outstanding performance record in home appliances, portable electric tools, aircraft components, business machines and many other motor-driven products.

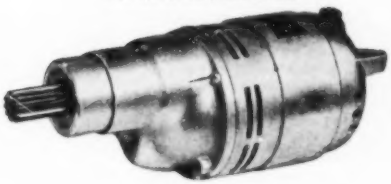
Behind this good performance is the fact that Lamb Electric Motors are *specially engineered* to provide the exact mechanical and electrical requirements for each product they drive.

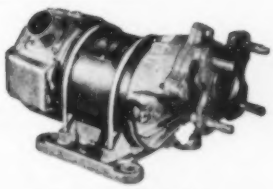
Other advantages often obtained with Lamb Electric special application motors are reduced product weight, compactness, and lower cost. THE LAMB ELECTRIC COMPANY • *Kent, Ohio*



Motor with high horsepower to low weight factor for either direct drive or use with external gear reduction.

Geared head motor with low output shaft speed for many slow speed heavy-duty drives.





High powered lightweight helical geared fuel transfer pump motor for aircraft and other services.

THEY'RE POWERING AMERICA'S *Finest* PRODUCTS

Lamb Electric
SPECIAL APPLICATION
FRACTIONAL HORSEPOWER **MOTORS**

To make YOUR product
work better... last longer
Use
FAIRFIELD
Gears
DESPITE all the care you lavish on the design and construction of your product, its successful performance may ultimately depend on a few, relatively small, gears. That's why it makes good sense to use only gears of established quality. FAIRFIELD GEARS have proved themselves "in use" on an almost limitless range of industrial products during the past 30 years. They are made-to-order—any type, and in a wide variety of sizes—to meet your special needs.
On your next gear problem, call in FAIRFIELD at the start. FAIRFIELD engineers are qualified to make expert recommendations that may save you time, money and future concern about gear performance in your product. Write for interesting, illustrated brochure.
Fine Gears made to order:
SPIRAL BEVEL • STRAIGHT BEVEL • HYPOID
HERRINGBONE • HELICAL • DIFFERENTIALS
SPUR • WORMS AND WORM GEARS
FAIRFIELD
FAIRFIELD
MANUFACTURING CO.
for FINE GEARS
313 S. Earl Ave. Lafayette, Indiana

charts on pages 150 and 151 give the value of resistance coefficients ϵ for fittings of different sizes. I am especially interested in the charts in Fig. 6 (A), (C), and (F). It may be noted that pipe-line designers often prefer to use flow velocity instead of the volume in U. S. gpm. Let us to compare values of ϵ derived from the chart (A) relating to elbows with corresponding data established by Davis (see Trans American Society of Civil Engineers, Vol 62).

	Elbows				Tees	
	Chart (A) d = 3/4 in.		Davis d = 2 in.		Chart (C) d = 3/4 in.	
gpm	V ft/sec	ϵ	V	ϵ	V	ϵ
1	0 73	15 5	2	1 63	0 73	15 0
2	1 46	8 0	3	1 64	1 46	8 0
3	2 18	5 4	4	1 63	2 18	5 9
5	3 64	3 5	5	1 65	3 64	4 3
8	5 82	2 8	6	1 54	5 82	3 7
10	7 28	2 6	8	1 65	7 28	3 5

The Chart (A) demonstrates that the values of ϵ drops with an increase in flow velocity; Davis' experiments show a constant value of ϵ not dependent on flow velocity. My experiments have established that in no case is ϵ below 1.0 and depends on the size of fittings alone. Values of ϵ increase as the size of the elbow decreases. In the table, values of ϵ are given for $\frac{3}{4}$ in. tees.

According to the research work of A. H. Gibson, the value of ϵ for Tees increases with higher flows. Chart (C) indicates a severe drop of ϵ with an increase in flow velocity. It would be desirable that the origin of such enormous deviations be made clear.

Referring to the Chart (F) giving ϵ for 6 in. bends, it may be noted that velocity effects on the resistance coefficient are not noted. In the following table values of ϵ are listed for 6 in. 90 degree bends according to Davis' experiments produced in the hydraulic laboratory of the University of Wisconsin.

Coefficient of Energy Loss ϵ

Ratio, R/D	Velocities V in ft per sec				Chart (F)
	3	5	10	16	
20	0 34	0 27	0 19	0 14	....
15	0 15	0 09	0 05	0 02	0 35
10	0 21	0 16	0 11	0 08	....
8	0 28	0 22	0 17	0 13	0 27
6	0 28	0 21	0 17	0 14	....
5	0 14	0 12	0 11	0 11	....
4	0 24	0 18	0 16	0 12	0 16
3	0 21	0 18	0 16	0 12	....
2 16	0 22	0 19	0 17	0 13	0 19
1 90	0 25	0 21	0 19	0 16	....

These values indicate that a minimum pressure loss is at ratio R/D = 5 not at R/D = 4 as Mr. Sverdrup says. In conclusion the writer is obliged to point out that establishing density in slugs (see Chart, page 173) is not recommended for practical purposes (as noted on page 73 of Marks' Handbook). It would be desirable to remove a typographical error on page 146 i.e. in the equation (1), the plus sign should be replaced by an equals sign.

—VICTOR TATARINOV
Pilsen, Czechoslovakia

To the Editor:

I have read Mr. Tatarinov's comments on my article and would like to make the following remarks:

The purpose of my article was to present mathematical formulas and graphical methods which would facilitate the rapid calculation of energy losses in hydraulic systems. Since in the United States the rate of flow of incompressible fluids is measured in U. S. gpm, the various formulas and charts are based on this unit. If the velocity was used, as Mr. Tatarinov seems to prefer, it would be necessary to compute the velocity in each individual fluid passage of the entire hydraulic system before the energy losses can be determined. When using the equation for Reynolds' number $R = 3162.419 \frac{G}{\nu_1 D}$, and the pressure loss equation, $P = 1.123 \times 10^{-3} G^2 S \Sigma \epsilon_n D_n^{-4}$ where $\Sigma \epsilon_n D_n^{-4}$ refers to the various fluid passages, the tedious work of computing the velocities is eliminated and a direct solution of the problem is possible. To further simplify the calculations the various flow equations can be solved rapidly by means of the charts in the article.

Mr. Tatarinov's statement that the effect of velocity is not considered in the coefficient of energy loss for bends is not quite correct. In the article, page 150, the coefficient of energy loss is given as the sum of the frictional coefficient of energy loss ϵ_f of the bend, and the coefficient of energy loss ϵ arising from the change in direction in flow. Such losses are: loss in the bend in transition from rectilinear to vortex motion, loss in the bend due to increased turbulence, loss in the straight pipe downstream from the bend in reestablishing of normal flow pattern, etc. The coefficient of energy loss for bends then is,

$$\epsilon_B = \epsilon + \epsilon_f$$

which also can be written,

$$\epsilon_B = \epsilon + f \frac{L}{D}$$

where the friction coefficient f is a

THIS BALDOR Streamcooled BALL-BEARING MOTOR
GIVES YOU EXTRA FEATURES AT NO EXTRA COST
Totally enclosed . . . ball-bearing.
Externally ventilated, fan-cooled, non-clogging. Dust-proof, splash-proof, lint-proof.
Standard NEMA dimensions.
Corrosion-resistant . . . inside and out. Specially impregnated to resist moisture.
Standard and face mounted end-plates, interchangeable for vertical or bracket type motors.
BALDOR ELECTRIC COMPANY
4353 DUNCAN AVENUE • SAINT LOUIS 10, MISSOURI
Baldor
MOTOR SPECIALISTS FOR 30 YEARS
BALDOR MOTORS ARE SOLD AND SERVICED IN MORE THAN 300 TRADE CENTERS

This gives you a clear "exploded" view of a basic double-circuit Twin Disc Hydraulic Coupling of the cast aluminum type. Small cast aluminum couplings are offered in sizes with capacities from ¾ to 40 hp . . . stamped steel couplings, in sizes to handle up to 700 hp.

Double Circuit for Double Duty

Twin Disc Hydraulic Couplings are the only industrial fluid drives with *double-circuit* construction...*

In transmitting power without a mechanical connection the hydraulic fluid flows in opposite directions in each of the circuits.

This "twin runner" principle results in three distinct advantages found in no comparable industrial fluid drive:

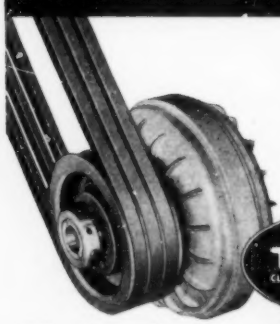
Thrust loads are perfectly balanced;

Capacity is greater for any given diameter;

Standard units are adaptable to standard SAE housings over a wide range of horsepower ratings.

There's a standard Twin Disc *industrial* fluid drive to fit your prime mover, and you can mount it in smaller space. In fact, Twin Disc Hydraulic Couplings are available in a wide variety of mountings for fractional hp to 700 hp applications. Write today for Bulletin i ..B.

*For certain fractional or small hp requirements, there is a Twin Disc Hydraulic Coupling with single circuit construction.



TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

function of Reynolds numbers and consequently also a function of velocity. The table below gives values of ϵ_B computed from the preceding equation for a 90 degree bend, $R = 6$ in., $D = 0.666$ in., and the kinematic viscosity 20 Centistokes. The tabulated values indicate that the value of ϵ_B diminishes with increasing velocity and increasing Reynolds numbers.

Velocity ft/sec	Reynolds numbers	Coefficient of energy loss ϵ_B
7	1800	0.985
8	2060	0.963
10	2570	0.926
15	3860	0.865
20	5150	0.826
25	6450	0.797
30	7720	0.775

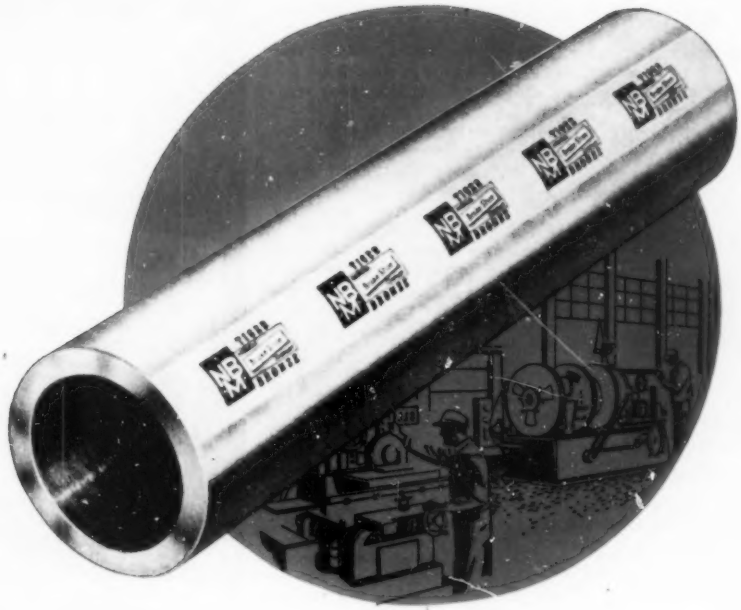
The flow conditions at a bend are relatively complex and results obtained by various investigators differ somewhat, indicating a minimum value of ϵ when R/D is between 3 and 5. The table Fig. 6F in the article gives a minimum value of ϵ when $R/D = 4$, which falls between these values.

The resistance curves for 90 deg flow through fittings are of a higher magnitude, which is to be expected due to the abrupt change in the direction of flow inside the elbow with consequent increase in turbulence. The fittings are of such design as to cause a contraction of the stream of fluid entering the fitting and an expansion leaving it. A high increase in turbulence is also present in a considerable length of straight pipe downstream from the elbow with consequent increase in energy loss. For flow of water and other fluids of low viscosity a value of $\epsilon = 1.3$ to 1.4 is commonly used for 90 degree elbows with sufficient accuracy. For flow of high viscosity fluids where the Reynolds number is low, the turbulence in the fitting is greatly reduced. However, the viscous resistance and velocity effects become more pronounced, and the value of ϵ is higher than that for water and other low viscosity fluids.

It is to be noted that Mr. Davis' experiments were conducted with water flowing through cast screw-elbows and therefore should not be confused with flow of oil of considerable higher viscosity, and through fittings of different configurations.

Mr. Tatarinov's statement that ϵ for fittings never can be less than unity is not in accordance with the findings of hydraulic investigators. The Crane Co. gives $\epsilon = 0.75$ for medium-screw elbows, $\epsilon = 0.60$ for long-sweep elbows, and $\epsilon = 0.42$ for 45 deg elbows using water.

Mr. Tatarinov is also in error in



Saved:

35% on Bronze Bar Stock!

How a machine shop saved 30¢ per pound through direct shipments of N-B-M "Tiger" Bronze Bars.

If you use bronze bar stock—and are looking for a quick way to reduce maintenance or production costs—you'll be interested in how a Michigan Machine Shop saved $700 in one year on bronze purchases alone!

They formerly bought finished bronze bar stock locally—but about a year ago started ordering "Tiger" Bronze direct from National Bearing Division.

Result? **Their cost was immediately cut 30¢ per pound . . . thanks to direct shipments. And equally important, these direct shipments are made overnight from one of our strategically located warehouses!**

This low price of N-B-M "Tiger" Bronze is made possible by these direct-to-you shipments . . . NOT by any sacrifice in quality. As a matter of fact, "Tiger" Bronze is highly anti-frictional to insure longer wear, and has physical properties that permit it to resist shocks, yet embed foreign particles.

13' lengths of "Tiger" Bronze are available in all popular sizes of machined or "as-cast" cored and solids, or "as-cast" hexagons . . . *available for prompt shipment of the bar size you want, when you want it.*

For longer—and lower cost—bearing service in your plant or product, try "Tiger" Bronze on your next order!

Write today for quotations and free catalog listing bar sizes, types, and "Tiger" Bronze alloy characteristics.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

4932 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST. LOUIS, MO. • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

CHECK LIST
of successful uses of

Luster-on® on Zinc

replacing Chromium, Cadmium or Nickel plate, offering Corrosion-Resistant, Brilliant Finish at Lowest Cost

- ✓ Cabinet hardware
- ✓ Small tools (wrenches, etc.)
- ✓ Auto body parts
- ✓ Bathroom hardware
- ✓ Aircraft metal parts
- ✓ Wire goods
- ✓ Refrigerator shelves
- ✓ Radio speakers, chassis, shields
- ✓ Television parts
- ✓ Electrical parts
- ✓ Air conditioning fans, guards, etc.
- ✓ Bolts, nuts, washers, rivets
- ✓ Builders' hardware
- ✓ Outdoor metal articles (fences, trailers, etc.)

also

- ✓ **Protective finishes**

covered by Federal Specifications for Army Signal Corps, Army Ordnance, Army and Navy Aeronautical.

THE Chemical CORPORATION
39 Waltham Ave., Springfield 9, Mass.

making the general statement "that establishing density in slugs is not recommended for practical purposes". In hydraulic engineering and in the research laboratory specific weight and density is widely used. However, some confusion seems to exist in the use of the terms. The specific weight of a fluid is defined as the weight per unit volume and is measured in lb per cu. ft. The specific weight is related to the specific gravity by:

$$\gamma = \gamma_1 S = 62.4S \text{ lb per cu in.}$$

where γ_1 is the specific weight of water, usually taken as 62.4 lb per cu ft. Density is defined as the mass per unit volume. In the English Gravitational System the unit of mass is the slug, and the unit of density is therefore slugs per cu ft. The density is related to the specific weight by:

$$\rho = \frac{\gamma}{g} \text{ slugs per cu ft}$$

where g is the gravitational acceleration. For convenience, the various flow equations in the article are derived in terms of the specific gravity, and the kinematic viscosity in Centistokes, which quantities are readily obtained.

In the development of hydraulic systems many variables are encountered which cannot be accurately evaluated; for example the exact length of the various fluid lines, number of bends and size of bend radii, exact number of fittings, etc. Some systems are also required to operate over a wide range of temperature which affects the viscosity of the fluid and the value of the various energy loss coefficients. For example, some aircraft hydraulic systems are required to operate from −60 deg F to +160 deg F, which results in a change in viscosity from 1,800 Centistokes to 7.5 Centistokes. It is therefore meaningless to strive for great accuracy in any phase of the calculations. It is, however, of importance that the final analyses are on the conservative side, and the coefficients must therefore be chosen accordingly. The various charts and tables should enable the designer to perform such analyses with sufficient accuracy for all practical purposes.

—NILS M. SVERDRUP
Hydraulic Engineer
Aerojet Engineering Corp.

Special Plastic Sheet

To the Editor:

We are seeking a source of supply for plastic sheet in colors. It must be flexible and transparent. There is available in retail stores a vinyl sheet

Important SAVINGS to VOLUME users of small parts

..like these

thanks to MULTI-SWAGE

If you need small tubular metal parts like these in large VOLUME, Bead Chain's MULTI-SWAGE Process can mean important savings to you.

Much Cheaper Than Solid Pins

Many prominent users of solid pins for electronic and mechanical purposes have cut costs by switching to Multi-Swaged *tubular* pins . . . without sacrificing strength or accuracy.

Typical Applications—

As terminals, contacts, bearing pins, stop pins, male-female connections, etc., in a wide variety of products such as Business Machines, Ventilator Louvres, Toys, Radio and Television Apparatus, Terminal-boards, Electric Shavers, Phonograph Pickups, etc.

Send part (up to ¼" dia. and to 1⅛" length) and your specs for a quotation or write for DATA BULLETIN.

B®

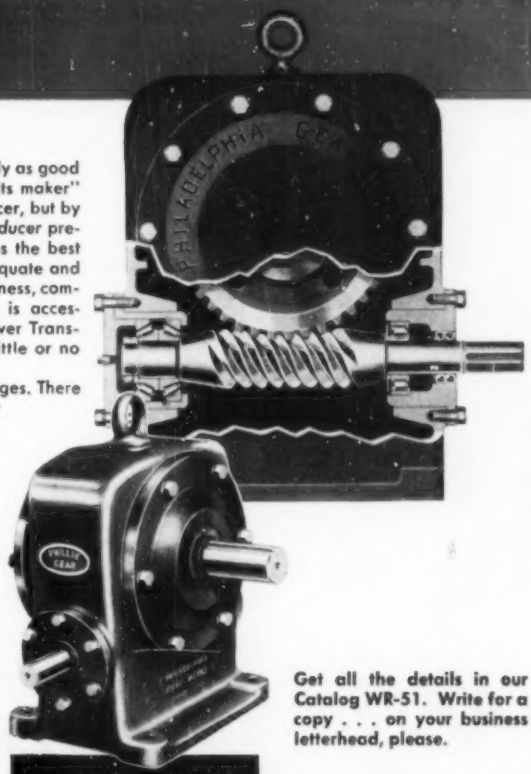
THE BEAD CHAIN MFG. CO.
92 Mountain Grove St., Bridgeport 5, Conn.

Manufacturers of BEAD CHAIN — the kinkless chain of a thousand uses, for pull and retaining chains and other industrial uses; plumbing, electrical, jewelry, fishing tackle and novelty products.

There's *far more* to a SPEED REDUCER than GEARS

It has frequently been said that: "any Reducer is only as good as the *experience and manufacturing facilities* of its maker" . . . *Gears are vitally important* in any Speed Reducer, but by themselves, they are *just Gears. A good Speed Reducer* presupposes also that it is properly engineered; it has the best anti-friction Bearings; the lubrication system is adequate and highly efficient; the Housing is designed for ruggedness, compactness and proper heat dissipation. The Unit is accessible—and it will deliver a high efficiency of Power Transmission over a long period of service life, with little or no attention.

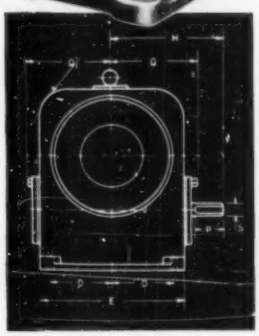
Philadelphia Reducers offer all of these advantages. There is a type and size of Philadelphia Worm Reducer for every industrial requirement.



FEATURES . . .

OF THE TYPE A-T-O AND R-T-O PHILADELPHIA WORM GEAR SPEED REDUCERS

- Units are available with Worm "above" or "below" the Worm Gear, or in Vertical Units.
- Worms are made of alloy steel with carburized, hardened and tempered threads—both shaft and threads are accurately and smoothly ground after heat-treatment.
- Worm Gears are of highest quality chill cast nickel-bronze.
- Bearings are anti-friction types (ball or roller) best suited for smooth, quiet, trouble-free operation (see cut-away illustration).
- Housings are quality grey iron—compact, neat, rigid and of ample radiating surface to prevent overheating.
- All units carry A.G.M.A. rating.
- Easy accessibility for removal of either Worm or Worm Wheel assemblies, from the housing.
- Lubrication by splash system to all moving parts, in oil-tight housing.
- Efficiencies as high as 96%.



Get all the details in our Catalog WR-51. Write for a copy . . . on your business letterhead, please.

Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.

NEW YORK • PITTSBURGH • CHICAGO • HOUSTON • LYNCHBURG, VA.

IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

Industrial Gears and Speed Reducers
LimiTorque Valve Controls

Sewall GEARS

CUSTOM MADE
For EVERY NEED

For best results, get in touch with Sewall engineers while your product is still on the drawing board. Close tolerances are efficiently maintained in the production of racks... sprockets... spur... spiral... bevel... Zerol bevel... worm gears. We furnish prompt estimates on any quantity.

Send for STOCK SPROCKET Catalog

E. B. SEWALL MANUFACTURING CO.
696 Glendale St. St. Paul 4, Minnesota.

10-Horsepower!

ONLY 97 lbs.

ONAN CK ENGINE

STEP UP PERFORMANCE of your engine-driven equipment with this rugged, lightweight prime mover. The Onan 10 HP Two-Cylinder 4-Cycle CK engine is inherently smooth - running delivers vibration - free power at all speeds. Alternate-firing, air-cooled. Built for long, heavy-duty service . . . with oversize bearings and rugged construction throughout. Unusually compact, to simplify installation.

OPPOSED DESIGN: Lighter weight, vibrationless performance.
OVER-SIZE BEARINGS: Extra large bearing area assures longer life.
PRESSURE LUBRICATION: Positive oil supply to all bearings.
SHORT, RIGID CRANKSHAFT: Fully counterweighted.
AXIAL FLOW COOLING FAN: Forces air over and around cylinders for maximum efficiency.

Write for Specifications

Onan PRODUCTS

D. W. ONAN & SONS INC.

6800 UNIVERSITY AVE. • MINNEAPOLIS 14, MINN.

which would be ideal except that it is transluscent, not transparent. This is of the same type as is sold for table covers and curtains. We are seeking a product already commercially available since the probable quantities required are small.

—THOBURN F. PETERSON
Watertown, N. Y.

Ed—The Bakelite Corporation makes two forms of vinyl sheet which are transparent. One is a rigid vinyl and the other is a cast film which has been used for transparent umbrella coverings.

You can obtain further information by writing or calling Mr. Irwin Morris, Bakelite Corp., 30 East 42nd St., New York, N. Y. The telephone number is Murray Hill 7-8000.

Response to "Surface Finish"

To the Editor:

Will you please inform us, if possible, where we might be able to obtain a stylus type surface roughness measuring instrument to be used in conjunction with measuring SAE roughness height values in micro inches. —DEANE N. JEWETT
Detroit Hardware Mfg. Co.

Ed—Two manufacturers of this type of instrument are: Physicists Research Co., Ann Arbor, Michigan; and Brush Development Co., Cleveland, Ohio.

Electro-Magnetic News

To the Editor:

In the May issue of PRODUCT ENGINEERING, page 172, you had an article on mechanized drives, which particularly referred to magnetic fluid and electromagnetic clutches. Please advise us of the manufacturers from whom additional data and information may be obtained.

We would also like more information on the fluid clutches referred to in the April issue.

—W. H. CANNARD
W. H. Cannard Co.

Ed—The magnetic fluid and electromagnetic clutches discussed in the May issue of PRODUCT ENGINEERING are manufactured by: Vickers Electric Div., Vickers, Inc., 1819 Locust St., St. Louis 3, Mo.; Eaton Mfg. Co., Cleveland, Ohio; and Warner Electric Brake & Clutch Co., Beloit, Wisconsin.

The clutch as mentioned in the story for the April number is the development of the National Bureau of Standards and information can be obtained from them.

FIELD TELEPHONE GENERATOR HANDLE
RADAR CAPACITOR PLATE
MILITARY VEHICLE CHASSIS FASTENERS
TRANSFORMER STUDS FOR ELECTRONIC AND COMMUNICATIONS EQUIPMENT
FUZE SCREWS
AMMUNITION CAN TOGGLE BOLT
STANDARD AN BOLT
STERLING SILVER RADAR CONTACT
SPECIAL ALUMINUM ALLOY AIRCRAFT SCREW

...need parts like these?

Here are a few parts, ranging from a relatively simple fuze screw to a specially designed radar capacitor plate, which should serve to illustrate the type of component that Scovill is set up to turn out.

If you have large volume requirements for ammunition components, parts for radar and communications devices, fastenings for aircraft, tanks, military vehicles —check with Scovill. You'll find experience and know-how, backed by a 50-year reputation as a reliable supplier of cold-headed fasteners and special parts.

For further information, you may find the coupon helpful. Or you may prefer to send more complete details about your current needs along with samples or blueprints. In any case, your inquiry will receive prompt attention.

BRASS CASTINGS

This Division also operates a modern sand casting foundry equipped to produce a wide variety of small brass castings.

Quotation can be made for machined as well as unmachined castings.

Send us your specifications and prints.

SCOVILL

WATERVILLE DIVISION

Industrial Fastener Sales

SCOVILL MANUFACTURING CO.

WATERVILLE 14, CONN.

Montclair, N. J., 20 Church St.
Detroit, 13755 James Cousens Hwy.
Wheaton, Ill., P. O. Box 242
Los Angeles, 2627 S. Soto Street
Cleveland, 6516 Detroit Ave.
San Francisco, 434 Brannan St.
Rochester 4, N. Y., 311 Alexander St.

Recessed Head Screws - Screws - Tapping Screws - Standard Machine Screws - Special Cold-Headed Parts

Mr. Warren F. Bice
Industrial Fastener Sales
Scovill Manufacturing Company
Waterville 14, Conn.

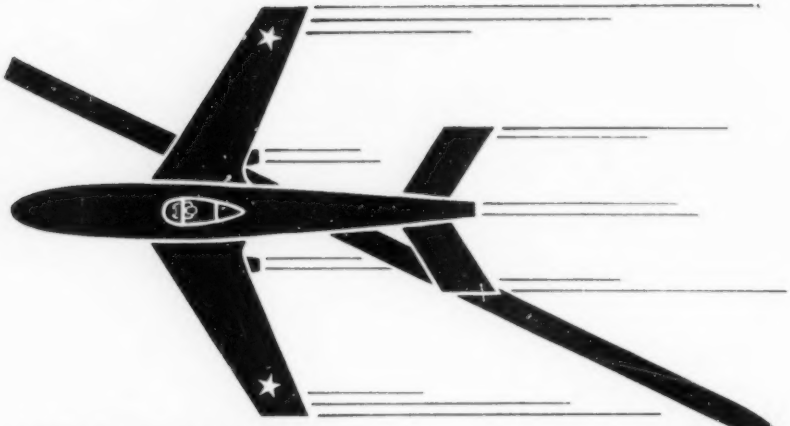
Please send me further information on your design and production facilities. I am interested in_____

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____



TUF-STUF'S best proving ground is in the air!

It pays to specify TUF-STUF aluminum bronze alloys for parts that must stand up

● Because they are both light and tough, TUF-STUF aluminum bronze alloys have proven invaluable in America's aircraft as valve-seat inserts, spark plug inserts, valve guides, gears and other vital parts.

If your product requires machined parts that are strong but light, resistant to corrosion, long wearing and resistant to oxidation even at high temperatures, then TUF-STUF is the right alloy for the job.

TUF-STUF alloys are furnished in the form of forgings, rods and screw machine parts. They fill Federal Specification QQ-B-666, Grade B, and several other variations. Because of the increased use and demand for both aluminum and copper, jobs carrying a Defense Order Number are receiving first consideration.

MUELLER BRASS CO.

PORT HURON 16, MICHIGAN

61

NEW BOOKS

Bibliography of Aerosols

Prepared by RICHARD A. STREHLOW, *Engineering Experiment Station, University of Illinois for the U. S. Atomic Energy Commission,* 10¾ x 8¼ *in.*

This collection of references on aerosols is based largely on the published work during the last quarter century. It classifies the books and articles on the basis of:

I. Properties—Acoustical, Electrical, Thermal; the Dynamics and size of particles.

II. Formation—prepartion methods: nucleation, condensation and growth.

III. Coagulation — Brownian motion turbulence; sonic, ultrasonic, and electrical methods.

IV. Measurement—sampling; particle size, mass and number.

V. Collection—air filters, sonic and centrifugal collectors.

VI. Electrostatic precipitation.

VII. Air pollution.

VIII. Meterology.

ASTM Standards on Rubber Products with Related Information

Prepared by ASTM Committee D-11 On Rubber Products. 640 *pages,* 6 x 9 *in. Published by American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.* $5.

This special compilation, issued May 1951, includes in convenient compact form the 100 widely used standard and tentative test methods and specifications which have been developed through the work of the American Society for Testing Materials Committee D-11 on Rubber and Rubber-Like Materials. The book should prove of great value to both producers and consumers of rubber products.

The following list of materials and subjects covered by standard tests and specifications will give some idea of the contents: Processibility Tests, Chemical Tests of Vulcanized Rubber, Physical Tests of Vulcanized Rubber, Aging and Weathering Tests of Rubber, Low-Temperature Tests of Rubber, Automotive and Aeronautical Rubber, Hose and Belting, Tape, Electrical Protective Equipment, Rubber-Coated Fabrics, Insulated Wire and Cable, Hard Rubber, Latex Foam, Sponge and Expanded Cellular Rubber, Rubber Cements, Rubber Latices,

Don't Overlook

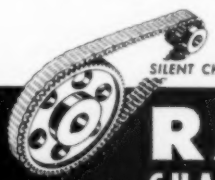
RAMSEY CHAINS

Speeds as high as 8929RPM, 7813 feet per minute have been handled successfully by Ramsey Chains. All because of the efficient roller bearing joint illustrated above. Note the curved contact surfaces of the pins, how they *roll* on each other as the chain engages the sprocket teeth. This action reduces friction to a minimum; cuts down the heat usually generated at high speeds at the chain joint; reduces wear and gives long life. Moreover, it compensates for the change of pitch created by chordal action, so that pulsations, so disastrous to chain life, are eliminated.

And, remember, Ramsey joint construction requires no special lubrication attention. No oil bath or forced system is necessary. Treat it as you would a frictionless bearing.

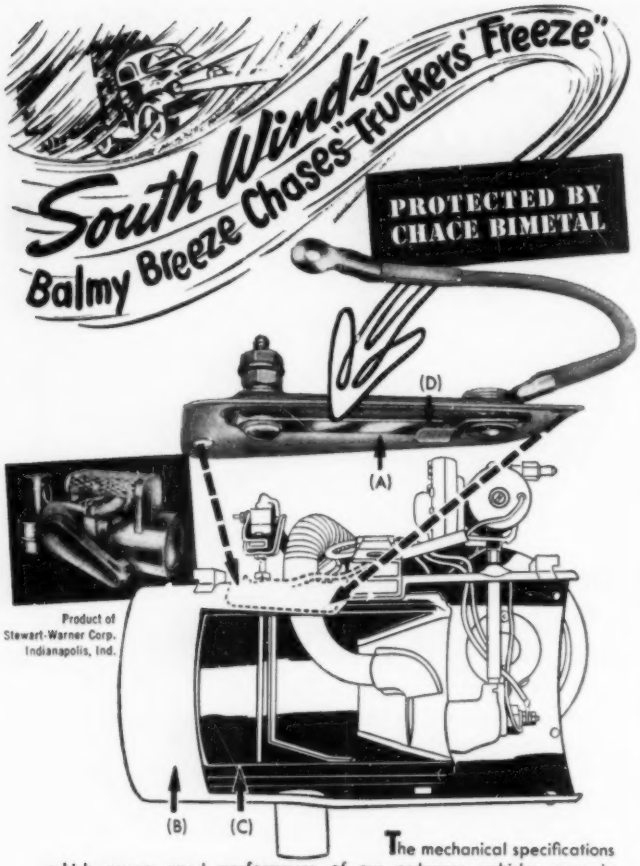
FREE APPLICATION MANUAL FOR ENGINEERS

This 60 page book gives you the range and scope of Ramsey Silent Chain Drives—tells you how to work out applications and includes the necessary data on chains, sprockets and pinions. Write for a copy today.



SILENT CHAIN DRIVES — FLEXIBLE COUPLINGS

RAMSEY
CHAIN COMPANY, INC.
5150 BROADWAY • ALBANY, N. Y.



The mechanical specifications which assure good performance of our ordnance vehicles even in Aleutian frigidity might be completely nullified by the frailty of the human system. In a word, a frozen trucker can't turn a switch. But Stewart-Warner's South Wind Model 978 puts an end to this hazard with this compact, light weight heating unit designed to produce a maximum heat output of 20,000 BTU per hour. Naturally, it accomplishes this quickly, with utmost serviceability and, of course, safety.

Speaking of safety, Chace Thermostatic Bimetal plays an important part in the safety requirements for such a combustion type heater. The bimetal blade (A) is placed so that the ventilating air flowing between the heater case (B) and heat exchanger (C) also passes over the bimetal. If the ambient temperature, the temperature of the ventilating air, exceeds 250 degrees, the bimetal element deflects upward and breaks the circuit. As the contact (D) is broken, the shut-off solenoid of the fuel control valve stops the flow of fuel until the cause of the over-heating is removed or corrected.

Stewart-Warner fabricates this simple element from one of the 29 types available in strips, random length coils or completely fabricated elements. For a complete treatise on the selection and design of elements for your temperature actuated devices, ask for our 64-page booklet. But before you proceed with actual design or tooling, consult the Chace Application Engineers.

W. M. CHACE CO.
Thermostatic Bimetal
1607 BEARD AVE., DETROIT 9, MICH.

Packing Materials, Nonrigid Plastics, Electrical Tests, Nomenclature and Definitions.

In addition to new material included in the book, many of the specifications and tests have been revised recently by the Society.

Particular attention is called to the inclusion of Emergency Alternate Provisions in this book. These Emergency Alternate Provisions in ASTM specifications are issued by the Society in the interest of expediting procurement or conservation of materials during the period of National Emergency. They are intended for use where they may be considered by the purchaser of the material as a permissible alternate for the specific application or use desired. They will not permanently amend the specifications but leave a choice.

Analysis of the Four Bar Linkage

JOHN A. HRONES, *professor of mechanical engineering; and* GEORGE L. NELSON, *assistant professor of mechanical engineering; The Massachusetts Institute of Technology.* 750 *pages,* 11 x 17 *in. Published jointly by The Technology Press of The Massachusetts Institute of Technology, Cambridge, Mass., and John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $15.

An exhaustive survey of the displacement and velocity characteristics of a four bar linkage in the range of operation where the driving crank makes a complete revolution while the follower crank oscillates. The charts presented make available information, in readily usable form, that enables designers to synthesize rapidly a linkage to do a specific job.

The data presented on the charts will relieve designers of the tedious task of solving equations to determine displacement, velocity, and acceleration of points on the connecting rod when proportioning a four bar linkage to achieve a desired motion. This volume includes more than 7,000 displacement paths with the velocity given at 72 equal intervals of drive crank angle along each path. The scope of usefulness covers about 500,000 solutions.

The authors have included a general discussion of the four bar linkage and, of course, an explanation of how the charts are to be used. Illustrative examples are given that are concerned with: The dwell period from straight-line path; The dwell period from circular-line path; Computer linkages; Double oscillating

crank; and Symmetrical-motion paths.

The fundamental purpose in publishing these valuable charts is to provide direct aid for designers in selecting a mechanism to produce a desired motion. With the desired motion known, the designer can rapidly thumb through the charts and find the link proportions that give motion characteristics similar to those required. When the designer finds that a number of possible mechanisms exist, he can with a little study select the one that is most suited for his application.

In cases where the linkage shown on a chart bracket the desired performance, models the ratios of which lie intermediate between the bracketing values can be built from cardboard or sheet aluminum, and the behavior of the modified linkage studied.

High Speed Photography

Volume 3, 1951, 160 *pages, soft cover,* 6 x 9 *in. Published by the Society of Motion Picture and Television Engineers,* 40 *W.* 40*th St., New York* 18, *N. Y.* $2.00.

This volume consists of eleven specialized papers which were prepared for the Society during the past year. Several of these papers are:

1. A survey of High-Speed Motion Picture Photography
2. Infrared Photography with Electric-Flash
3. The Stroboscope as a Light Source for Motion Pictures
4. High-Speed Photography of Reflection-Lighted Objects in Transonic Wind Tunnel Testing
5. A 100,000,000 Frame Per Second Camera
6. Photography in the Rocket-Test Program
7. The High-Speed Photography of Underwater Explosions.

Following these papers is an extensive and selective bibliography on high speed photography including foreign publications. This list is divided into: Cameras, Lighting, Oscillography, Schlieren; X-ray and Techniques. In addition, the papers which were published in the earlier Volumes 1 and 2 are alphabetically arranged.

Vibration and Shock Isolation

CHARLES E. CREDE, *chief engineer, The Barry Corp., Watertown, Mass.* 9⅜ x 6 *in.,* 330 *pages. Published by John Wiley and Sons Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $6.50.

With the ever increasing demand for more precise equipment and ma-

CYCLOHM MOTORS
PLAY IMPORTANT PART
IN SPEEDING
COMMUNICATIONS FOR
WESTERN UNION
You can tell a motor by the company it keeps!
EMC and CYCLOHM
FRACTIONAL H.P. MOTORS, UNIVERSAL AND DIRECT CURRENT 1/1000 TO 1/3 H.P.
SHADED POLE, 1/2000 TO 1/15 H.P.
INDUCTION TYPES, 1/1400 TO 1/3 H.P.
Utilizing CYCLOHM precision induction motors in the miniature facsimile machines, called the Desk-Fax, Western Union has brought high speed telegraph service to many Government Agencies and Defense Plants.
With a Desk-Fax Machine, only 10"x11"x7" in size, messages can be transmitted and received immediately from desk or office.
Model 2500 Cyclohm Synchronous Induction Motors are used as the drive mechanisms for the message drum. Because perfect operation is absolutely essential, Cyclohm motors were chosen from exhaustive tests of many motors.
EMC Universal, Direct Current and Shaded Pole Motors and CYCLOHM Induction Motors are currently being used by leading manufacturers for more than 300 applications—communications equipment, cameras, projectors, sewing machines, mixers, fans and blowers, portable power tools, adding machines and scores of others. Check your fractional H.P. requirements with us today and be sure to write for a copy of our latest catalog.
HOWARD
DEPT. PE-5 • HOWARD INDUSTRIES, INC. • RACINE, WISCONSIN
DIVISIONS: EMC ELECTRIC MOTOR CORP. CYCLOHM MOTOR CORP.

2 out of 1,000 uses

for remarkable U. S. Royalite the Versatile Thermoplastic

ROYALITE
Auto Fender Stone Guard
In this application, Royalite's toughness, hardness and ability to withstand great impact without splintering make it especially valuable in the automotive industry.

There is virtually no end to the uses of U. S. Royalite. Designers and engineers say it gives them new freedom of design, lets them attain an efficiency often never possible with any other thermoplastic.

Royalite is obtainable either standard or flame-resistant. It can be sawed, sheared, sanded, punched, nailed, bolted, riveted, sewed and cemented. Stiff or flexible, hard or soft, it can be formed on standard equipment with conventional techniques. The engineering staff of United States Rubber Company will be glad to work with you or advise you on any application of Royalite you may suggest.

ROYALITE IS:

- ★ Standard or flame-resistant
- ★ Lightweight
- ★ Non-splintering
- ★ Non-Warping, non-corrosive
- ★ Tough
- ★ Highly resistant to impact
- ★ Waterproof, stainproof
- ★ Not affected by oils, most acids, alkalies
- ★ Available in different colors, for easy classification
- ★ Stable under changing atmospheric conditions
- ★ Exceptional electrical insulating properties
- ★ Low rate of heat conductivity

ROYALITE
Shaved Ice Chute
Light in weight, non-warping, waterproof—this unique molded ice chute is perfect for the job. Fabricated by Regal Plastics Co., Kansas City, Missouri.

u.s. Royalite®
STANDARD OR FLAME RESISTANT

SEE NEXT PAGE FOR LIST OF U. S. ROYALITE FABRICATORS➡

UNITED STATES RUBBER COMPANY
2638 North Pulaski Road • Chicago 39, Illinois

u.s. Royalite

CONSULT THESE EXPERIENCED FABRICATORS OF ROYALITE

CALIFORNIA
Horace L. Blackman Co., 287 So. Robertson Blvd., Beverly Hills
General Plastics Corp., 723 W. Broadway, Glendale 4
Engineering Plastics Co., 1475 El Mirador Dr., Pasadena 3
National Plastics Industries, 425 Divisadero St., San Francisco
Hollywood Plastic Arts, 503 W. Olympic Blvd., Los Angeles 15
Swedlow Plastics Co., 5527 District Blvd., Los Angeles 22
Westwood Craftsmen, Inc., 2043-45 Pontius Ave., Los Angeles 25
Associated Mfg. Co., 541 S. Fair Oaks Ave., Pasadena 2

COLORADO
Pikes Peak Plastic, 5 W. Cucharras St., Colorado Springs
Denver Plastics, Inc., 260 S. Dale Court, Denver 9

FLORIDA
Plastics Design & Mfg. Co., Box 61, Tallahassee

GEORGIA
Gladwin Plastics, 542 Courtland St., N.E., Atlanta

ILLINOIS
Arrem Plastic, 1539 N. Throop St., Chicago 22
Associated Plastics Fabricators, 164 N. May St., Chicago 7
L. A. Goodman Mfg. Co., 131-145 W. 63rd St., Chicago 21
Laidman-Krispin Co., 1308 N. Halsted St., Chicago 22
Cortland Industries, Inc., 4545 W. Cortland St., Chicago 39
Neo Products Co., 2534-38 S. Kedzie Ave., Chicago 23
O-Lin Products, 3755 Kedzie Avenue, Chicago 18
Precision Plastic Products Inc., 628 W. Lake St., Chicago 6

INDIANA
General Plastics Corp., 1400 N. Washington, Marion

MARYLAND
Fawn Plastics Co., 2902 Hamilton Ave., Baltimore 14

MICHIGAN
Cadillac Plastic Co., 651 W. Baltimore, Detroit 2
Imperial Industries, 4435 Walker Ave., Wayne
Klise Mfg. Co., 50 Cottage Grove S.W., Grand Rapids 2
Reynolds Plastics, Inc., 3445 W. Forth St., Detroit
Fabri-Kal, 242 East Kalamazoo Avenue, Kalamazoo
Woodall Industries Inc., 7565 E. McNichols Rd., Detroit 34

MINNESOTA
T. O. Plastics, 58th & Longfellow, Minneapolis
Plastics, Inc., Chestnut & Ryan Sts., St. Paul 2

MISSOURI
Regal Plastics Co., 710 Main St., Kansas City

NEBRASKA
Omaha Plastics Co., 1470 S. 16th St., Omaha 9

NEW JERSEY
Sillcocks-Miller Co., 10 W. Parker Ave., Maplewood
Stokes Molded Products, Inc., Taylor St. at Webster, Trenton 4
Thermacote Co., 320 Jefferson St., Newark 5
Van Beek Industries, 23 Park St., Orange

NEW YORK
Bassons Molded Products, 1424 W. Farms Rd., New York 60
Copeland Displays, Inc., 537 W. 53rd St., New York 19
Curbell Inc., 1700 Elmwood Ave., Buffalo 7
Dual Fabricators Corp., 808 Driggs Ave., Brooklyn 11
Dura Plastics Inc., 1 W. 34th St., New York 1
Durable Formed Products, Inc., 329 Canal St., New York 13
Mastercraft Plastics Co., Inc., 95-32 150th St., Jamaica 4
Steiner Plastics Mfg. Co., 47-30 33rd St., Long Island City 1

OHIO
Fabri-Form Co., Box 36, Cambridge
The Baxter Company, 15 E. 2nd Street, Cincinnati

PENNSYLVANIA
Halsen Mfg. Co., 5919 Webster St., Philadelphia
Lee Plastics, A and Lippincott St., Philadelphia 34
Pearson-Berlinghof, Inc., 18 North State Street, Newton
The Bell Plastics Co., Inc., 600 Heinz Street, Pittsburgh 12

TENNESSEE
Plasti-Line, Inc., Jacksboro & Broadway, Knoxville 18

TEXAS
Plastic Engineering Co., 2101 69th St., Houston 11
Plastic Products of Texas, 1400 Cedar Springs, Dallas

WASHINGTON
K. B. Plastics, Inc., 1817 So. 1st St., Yakima
Mason Plastics Company, 1121 Westlake North, Seattle

WISCONSIN
Midland Plastics Inc., 227 N. Water St., Milwaukee 2

The United States Rubber Company at 2638 North Pulaski Road, Chicago, Illinois, has complete Engineering, Designing, and Styling Departments to assist fabricators on the technique to employ, and in the art of fabricating most efficiently with ROYALITE.

chinery, the designer is often confronted with problems of isolating vibrations or sound or reducing the effect of shock loads. This book should prove useful to those with problems of this type. The material covered is based on Mr. Crede's wide experience in this field. During World War II he worked for the Navy Department's Bureau of Ships on the problems of protecting vital equipment from severe shock. In his present position he has gained an excellent background with the wide applications of isolators in commercial and military fields.

This book emphasizes the principles of isolation as well as the design and application of such isolators rather than on general theory of vibration. The treatment is complete and arranged to be most practical. Chapter 1 is introductory, describing the basic mathematical and physical concepts. Chapter 2 and 3 discusses the fundamentals of vibration and shock isolation. In Chapter 4, non-linear and damped systems are covered along with damper design and sound isolation. The design of isolators is described in Chapter 5 in conjunction with the properties of various materials used in isolators. The final chapter is devoted to many specific applications. It is largely descriptive and emphasizes the importance of the basic theory developed in earlier chapters.

Pressure Pipe Code

Prepared by the Sectional Committee on Code for Pressure Piping. B31; *soft cover,* 8½ x 11 *in.,* 110 *pages;* ASA B 31.1-1951. *Published by the American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.* $3.50.

Following the publication of the 1942 code and the supplements 1 and 2 in 1944 and 1947, there appeared the need to clarify many inquiries that arose in the interpretation of code requirements. In addition, the increase in the severity of service conditions and the development of newer materials along with design improvements for higher requirements pointed toward more extensive changes in the code. As a result, this committee was reorganized in 1948 to intensively review the existing code and to clarify all conflicting specifications.

The principal purpose of this code is to serve as a guide in the preparation of specifications or regulations for state or municipal agencies. This code sanctions the use of new materials and construction processes which have proven to have safety characteristics

Wherever it's HOT specify Sicon

NEW IMPROVED SILICONE-BASE HEAT-RESISTANT FINISH

Protects Stewart Warner's New Saf-Aire Wall Furnace

Quality finish specifications for this heating unit called for a coating that would stand 500° and still retain its color and gloss—a temperature far above that incurred in normal operation. Ordinary heat resistant coatings failed. SICON *Ivory* and SICON *Beige* worked perfectly...just as SICON has solved so many other finish problems. *Write for dynamic proof of SICON'S amazing stability under heat! New Brochure now ready.*

Sicon

Silicone-Base Finish is manufactured exclusively by

MIDLAND INDUSTRIAL FINISHES CO.

Waukegan, Illinois

ENAMELS • SYNTHETICS

LACQUERS • VARNISHES

equal to or superior to those previously specified. It is suggested that at least the minimum code requirements be maintained.

This book is divided into seven sections. In piping systems, these sections cover Power, Gas and Air, Oil, District Heating, and Refrigeration. Following the section on Fabrication Details, the final section discusses the specification ... materials.

Civil Defense In Modern War

AUGUSTIN M. PRENTISS, *Ph.D., Brigadier General, United States Army (Retired). 429 pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y. $6.*

In this vitally important and timely book General Prentiss presents a program covering every major aspect of civil defense against atomic, bacterial and chemical warfare. Part I, dealing with modern air warfare, gives a comprehensive picture of the types of aircraft used in modern war, including pilotless bombers and guided missiles, the weapons employed by these aircraft, and the ways in which they would be dispersed. Among the destructive agents discussed are high explosives, chemicals such as poison gases, incendiary bombs, harmful bacteria, and atomic bombs.

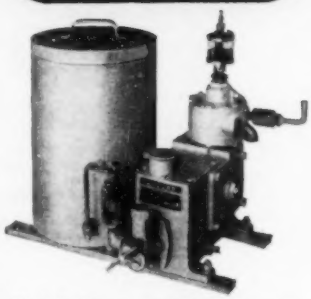
Part II, Civil Air Defense, presents methods of protecting industries, communities, homes, and individuals against various destructive weapons, with emphasis on combinations of protective measures wherever possible. Part II, Organization for Civil Defense, is a complete guide to a Civil Defense program for national, state, and local governments. Here General Prentiss shows how the various Civil Defense units are set up and how they operate—the Warden Service, the Medical and Health Service, etc.—emphasizing the importance of local governments and individual citizens in the future security of our nation.

Advanced Fluid Dynamics And Fluid Machinery

R. C. BINDER, *Ph.D. Professor of Mechanical Engineering, Purdue University. 426 pages 5½ x 8½ in. Published by Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y. $8.*

One frequently finds a serious gap between the usual first treatment of a subject and the problems and reference material encountered in engineering practice and current literature.

WHAT NEXT? GAST rotary AIR MOTORS run on gas pressure to drive liquid pumps!



Alert designers are still finding new ways to exploit the unique advantages of Gast Air Motors. Look at this example:

PROBLEM: Find explosion-proof drive for McCord Chemical Pump, used in oil fields. Electricity often not available.

SOLUTION: Gast Air Motor, driven by pressure of natural gas from field, turns 250 r.p.m. to drive liquid pump through worm gear.

RESULT: Dependable "free" power — low cost for motor.

What next? Perhaps you'll find a job that can be done *better* with Gast rotary-vane Air Motors. Remember these unique characteristics: They're compact, explosion-proof, widely variable in speed. Overloads can't burn them out! Sizes from 1/20 to 3 H.P., some reversible. Write for details — "Air may be your Answer!"

Gast Application Ideas Booklet — showing 26 design problems solved — sent upon request.

SEND OUR CATALOG IN SWEET'S FILE

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

AIR MOTORS (TO THREE H.P.) • COMPRESSORS (TO 30 LBS.) • VACUUM PUMPS (TO 28 INCHES)

GAST MANUFACTURING CORP., 139 Hinkley St., Benton Harbor, Mich.

One of the objectives of this book is to fill that gap in the field of fluid mechanics.

The author has divided the material into three parts: Part I is a direct extension of the usual first treatment in fluid mechanics, it might be classed as engineering fluid mechanics or dynamics. One-dimensional compressible flow, flow with friction and heat transfer, and boundary layer flow.

Parts II and III were arranged to provide flexibility in study; either can be taken directly after the first section. Part II considers the selection, operation and design of fluid machines.

Fluid machines may be divided into two main types: the dynamic or kinetic type, and the positive-displacement or static type. Part II is concerned with dynamic machines of the steady flow type: It includes such items as turbines, centrifugal cams and pumps, centrifugal and axial-flow compressors, fluid couplings and torque connecters and jet pumps and ejectors. This section should be helpful in that it gives information about common machines and also shows application of fundamental ideas and relations previously presented.

Part III is really an extension of Part I, although its somewhat more analytical than the first part because of the greater complexity of the material being treated. Two-dimensional flow without friction and the general analytical relationships for viscous flow are included. The final chapter consists of a brief summary of vector analysis-tool that has only recently become appreciated by any number of engineers.

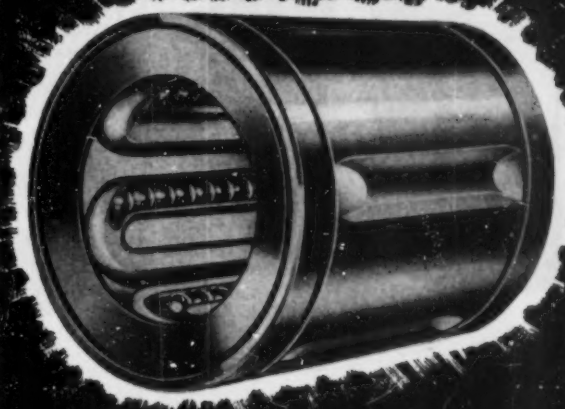
Practical Design of Mechanical Elements

Prepared under supervision of A.S.T.E. Book Committee, American Society of Tool Engineers, Detroit, Mich.; EDWARD W. ERNST, *Chairman,* FRANK W. CURTIS, *Vice Chairman, and* FRANK W. WILSON, *Editor-in-Chief. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y.* $3.

Many men in manufacturing are sharply specialized in the design work requiring access to the theory formulas, tabulations, and standards for mechanical elements. Therefore, they may feel that their present responsibilities do not require the Handbook's complete coverage of manufacturing.

This volume consists of eight comprehensive and clearly written chapters dealing with: screw threads, gears, splines and serrations, cams, ball and

BALL BUSHING



The BALL BEARING for your

LINEAR MOTIONS

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A BALL BUSHINGS.

And now hundreds of original equipment manufacturers use the low cost Commercial Series B BALL BUSHINGS which were developed for support of linear motions in competitively priced, volume manufactured products where super precision is not essential.

Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product. Up-date your design and engineering with BALL BUSHINGS!

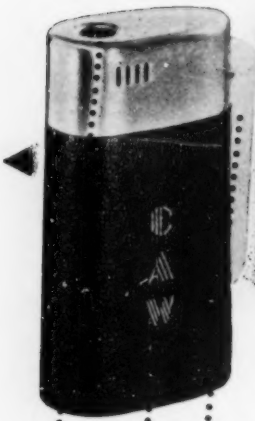
LOW FRICTION • LONG LIFE
ELIMINATES BINDING AND CHATTER
SOLVES SLIDING LUBRICATION PROBLEMS
LASTING ALIGNMENT • LOW MAINTENANCE

Now manufactured for 1/4", 1/2", 3/4", 1" and 1 1/2" shaft diameters.

Write for descriptive literature and the name of our representative in your city

THOMSON INDUSTRIES, INC., Dept. F
MANHASSET, NEW YORK

PROGRESSIVE MANUFACTURERS USE BALL BUSHINGS – A MAJOR IMPROVEMENT AT A MINOR COST



Here's how Twin City Castings CUT ASSEMBLY COSTS on Brown and Bigelow's Rediflame Gas Lighter

You get *more* than castings that meet specifications from Twin City. Over 30 years' experience has given Twin City Die Casting Co. the die-making ingenuity and castir.. know-how that not only holds castings to tolerances . . . but *cuts production costs* and *HELPS MAKE SALES!* Here's how Twin City applied that experience to casting parts for Brown & Bigelow's popular Rediflame gas lighter.

THIS WAS THE JOB:

Cast a light-weight desk model lighter body holding all tolerances. Every casting to be smooth and accurate to accommodate seals and "O" rings. Body to be built around two large *opposing* cores. Eliminate shrink drop. Cast top and lever to specifications, lever to be plated.

THIS WAS TWIN CITY'S ANSWER:

All specifications were met and held. Rediflame body was cast in aluminum, lever and top in zinc. By working with the customer's engineers, additional cores were included in the die to eliminate assembly operations. In other places, drill spots were cast. "O" rings sealed perfectly as required.

HERE'S WHAT THIS CAN MEAN TO YOU!

Twin City's ability to work with your engineers to cut your final production costs . . . its years of experience and casting know-how can show real *profits* for you. Get all the facts, contact Twin City Die Casting Co., oldest die-casters in the upper Midwest. Let Twin City engineers demonstrate how experience can pay off for you.

TWIN CITY DIE CASTINGS CO.

3351 TALMAGE AVE. S.E. · MINNEAPOLIS 14, MINN.

roller bearings, sleeve bearings and bushings, springs, mechanics and physics. Supplementing the text there are line drawings, tables and charts; lists of nomenclature, terminology, and definitions; symbols; equations; as well as methods, practices and procedures.

Each topic is discussed at length and in detail. For example, the chapter on ball and roller bearings includes data on load distribution in bearings, elastic deflection of bearings, forces and motions in bearings, carrying capacity of antifriction bearings, equivalent loads (including dynamic and static loads), bearings selection, lubrication and sealing devices, mounting and dismounting bearings and bearing failures.

Thermodynamics of Fluid Flow

NEWMAN A. HALL, *University of Minnesota.* 280 *pages, hard cover,* 5¾ x 8¼ *in. Published by Prentice-Hall, Inc.,* 70 *Fifth Ave., New York City.* $7.35.

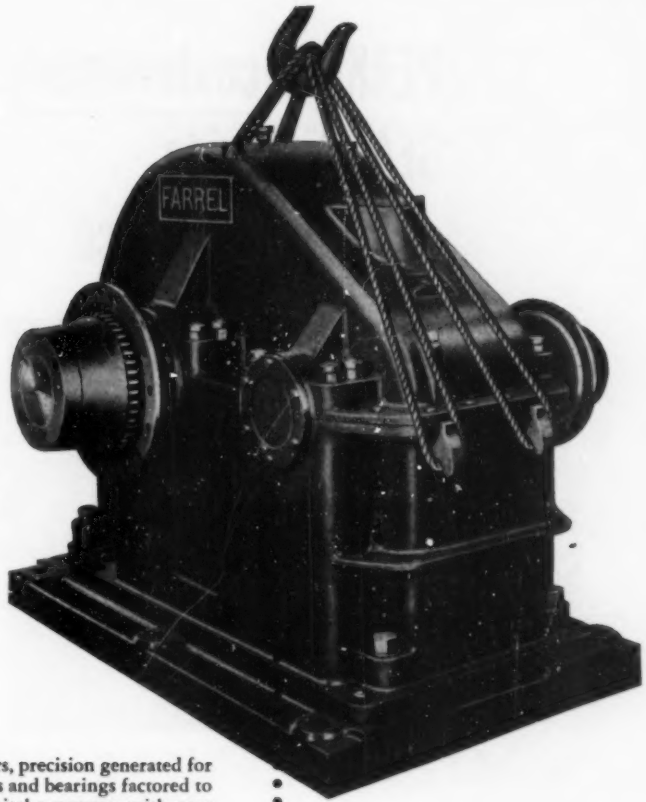
Two of the major basic techniques of analysis in engineering science today are fluid mechanics and thermodynamics. This has been due to developments in recent years which have served to emphasize that an adequate facility in the analysis of fluid flow is dependent on a knowledge of both fields. While much has been written from the two separate viewpoints, it is only recent that a systematic description of the thermodynamics of fluid flow has appeared.

This text is designed to provide an introduction to the combined field. It is for students who have the fundamentals of both fluid mechanics and thermodynamics, although a certain amount of review of each is included. The material is organized with major emphasis on theory. A number of examples are included to show the application of the theory to various practical problems. Reference is made to several handbook sources for more complete information in design and practical applications.

In writing this book the author makes two major assumptions: (1) that the flow is steady and (2) that the flow is one-dimensional. This approach has a wide range of applications since most internal flow analysis can be treated in at least a preliminary way on this basis.

The thermodynamics of fluid flow, (other than perfect gases, such as liquids and imperfect gases), is considered with a view to emphasize fundamental principles. For example, the

FARREL® SPEED REDUCERS



THEY ARE MADE **with Farrel-Sykes gears, precision generated for smooth, quiet operation; with shafts and bearings factored to safeguard against interruption of vital processes; with gear cases proportioned to withstand repeated heavy peak loads. These are standard features of design, incorporated to assure long, trouble-free performance under normal operating conditions.**

FOR UNUSUALLY SEVERE SERVICE, THEY ARE MADE **with gears, shafts, bearings, and even some housing dimensions, proportioned to meet specific load, speed and operating conditions. Because of this flexibility in design, Farrel speed reducers have provided the solution to innumerable application problems.**

WRITE FOR COMPLETE DETAILS. ***Ask for a copy of Bulletin 449—no cost or obligation.***

are made to fit your requirements

F3-671

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT
Plants: Ansonia and Derby, Conn., Buffalo, N.Y.
Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Cleveland, Detroit, Chicago, Portland (Oregon), Los Angeles, Salt Lake City, Tulsa, Houston, New Orleans
Farrel-Birmingham

PERKINS custom-made GEARS provide + performance

MAGNAFLUX INSPECTION: Accuracy and variety of devices used in our inspection department are of prime importance in maintaining PERKINS' quality standards.

Write for our bulletin "Perkins Gears" for full data on our gear engineering facilities

Perkins custom-made Gears—for aircraft engines or for any other application—are first and foremost the product of a reliable and experienced gear engineering organization. Thus they provide a consistent plus in the performance of the product in which they are installed.

Our equipment and facilities coupled with the individual skills of New England craftsmen enable us to fill orders for any type of gear in any quantity, any size and any material—metallic or non-metallic.

Have us quote on your requirements.

PERKINS MAKES:
Helical Gears
Bevel Gears
Ratchets
Worm Gears
Spiral Gears
Spur Gears with shaved or ground teeth
Ground Thread Worms

PERKINS MACHINE & GEAR COMPANY

WEST SPRINGFIELD, MASSACHUSETTS

Mach number is defined for the general fluid and it is shown that the critical properties associated with a Mach number equal to one are significant for all fluids. The various flow losses such as wall friction and turbulent separation are described both dynamically, and also from the energy viewpoint as the internal entropy increases. A comparison is made with entropy coefficients and various loss coefficients. A common basis for flow losses is thereby established.

The problems which are included at the end of each of the 12 chapters represent an important part of the text for students. Although this material has been organized as a text, it should serve as reference material for those in research and development in propulsion, process industry, and other fields dependent on flow systems.

Aircraft Designers' Data Book

LESLIE E. NEVILLE, *Curtis Wright Corp., 534 pages, 8½ x 11 in., Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y.* $10.

Here is an outstanding handbook which offers a unique, graphic presentation of detail designs that will enable engineers to grasp the design features of a selected group of typical domestic and foreign aircraft and power plants quickly and easily.

In convenient reference form 788 illustrations and sketches of structural details help the engineer embarking upon a new design to determine quickly what has been done before in the area in which he is working. The book is arranged in chapters corresponding to the basic components of the aircraft—and provides pertinent information on wing and auxiliary surface design—empennage design—fuselage, body, and hull design—landing-gear and control-system design—rotating wing aircraft and turbine engines, etc.

This vast compilation of design analysis material has been culled from the pages of AVIATION and WINGS magazines and supplemented with additional current data from manufacturers on more recent aircraft. The aircraft selected for these studies represent many different types developed in the past few years in this country and abroad . . . land planes and seaplanes of metal and composite construction, single engine, twin engine, and aircraft having four or more engines . . . and include such aircraft as the Lockheed Constitution, Avro transport, and other advanced designs.

Van Huffel
cold-formed metal tubing and shapes
are profitably employed
in hundreds
of

appliances

In the never-ending struggle to free
the modern home-maker from drudgery, Van Huffel
metal shapes and tubing have made
a distinctive contribution. For nearly 50 years,
designers of household appliances have
been specifying Van Huffel for items that
demand strength and style plus fabrication
simplicity and economy. Because of
Van Huffel's experience and versatility,
today's woman can look forward
to an even brighter future.

VAN HUFFEL

TUBE CORPORATION • WARREN, OHIO

WELDED, LOCK SEAM, OPEN SEAM, BUTTED TUBING, SHAPES AND MOULDINGS

Take a tip from the people who run Railroads

YOU can date a renaissance in railroad equipment from the time when the first stainless steel streamliners appeared in the 1930's. In stainless steel, railroad management found a material that introduced a whole new set of values . . . so strong that it permits lightweight construction which saves large amounts in fuel costs . . . so corrosion-resistant and everlasting that cleaning, maintenance and depreciation costs are cut to the bone.

The public is benefitted with faster, safer, more comfortable and modern travel accommodations; the roads benefit because stainless steel saves on expenses and increases profits. Today you'll find Allegheny Metal used not only for entire trains, but in dining-car kitchens, sleeping-car equipment, refrigerator cars, and tank cars for the transportation of milk, chemicals, etc.

Rail equipment is only one of the vital uses for stainless steel in general industry and the national defense. In the past decade, we have spent many millions to increase the supply of Allegheny Metal and other alloy products, and are in the process of spending millions more. ● In the national interest, let us help you to use stainless steel most efficiently, and make the available supply go farther.

* * * * *

Complete technical and fabricating data—engineering help, too—are yours for the asking from Allegheny Ludlum, the nation's leading producer of stainless steel in all forms. Branch Offices are located in principal cities, coast to coast, and Warehouse Stocks of Allegheny Stainless Steel are carried by all Joseph T. Ryerson & Son, Inc. plants. ● *Address* Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Penna.

W&D 3149

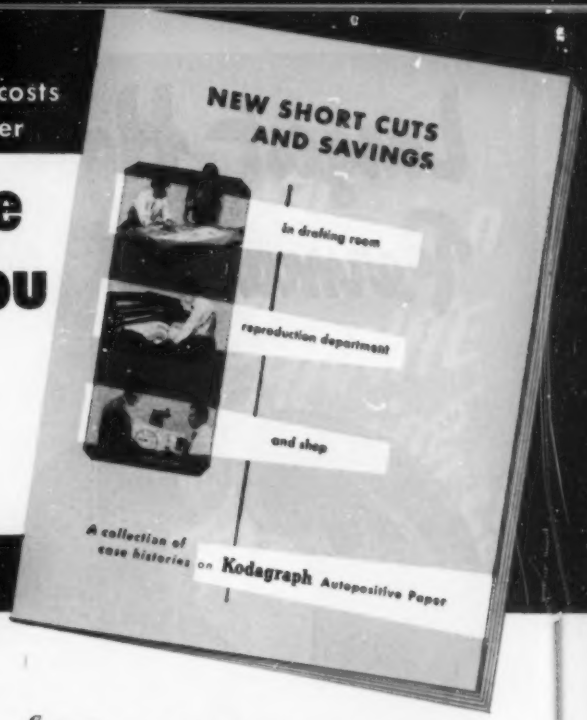
You can make it **BETTER** with

Allegheny Metal

AL TIME-TESTED STAINLESS STEEL

Thousands of companies are cutting costs with Kodagraph Autopositive Paper

...this new, free booklet shows you *how*


NEW SHORT CUTS AND SAVINGS
in drafting room
reproduction department
and shop
A collection of case histories on Kodagraph Autopositive Paper

Here you'll find a selection of case histories illustrating the many different ways industry is using Kodagraph Autopositive Paper—the low-cost photographic intermediate material...which gives you positive copies *directly;* which can be handled in room light...and printed with existing equipment.

Interesting and Profitable Reading

how the American Brake Shoe Company (Kellogg Div.) . . . broke the bottleneck in reproducing blueprints.

how the Cleveland Crane and Engineering Company . . . saves creative drafting time.

how the Cooper-Bessemer Corporation . . . reduced the possibility of costly reading errors in the shop.

how the Crompton & Knowles Looms Works . . . simplified its engineering drawing files.

how the Ford Motor Company . . . saves $75,000 per year in retracing costs.

how the Heald Machine Company . . . produces photographic intermediate prints at a new low cost.

how the Ingersoll-Rand Company (Compressor Div.) . . . salvages old drawings . . . employs ingenious short cuts in drafting.

how the M. W. Kellogg Company . . . assures photo-lasting intermediates for its overseas branches.

how the State of Virginia, Dept. of Highways . . . saved thousands of man-hours in its drafting room.

how Palmquist & Wright . . . "insures" its drawings at low cost.

Valuable information for every engineer, draftsman, and print-room supervisor

On every page of this concisely written, well-illustrated booklet, you'll find factual information which can be converted readily into savings in your company.

So write today for your free copy of "New Short Cuts and Savings."

Kodagraph Autopositive Paper

"THE BIG NEW PLUS" in engineering drawing reproduction

MAIL COUPON TODAY

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY, Industrial Photographic Division, Rochester 4, N. Y. 15

Gentlemen: Please send me a copy of your illustrated booklet, "New Short Cuts and Savings."

Name_____ Position_____

Company_____

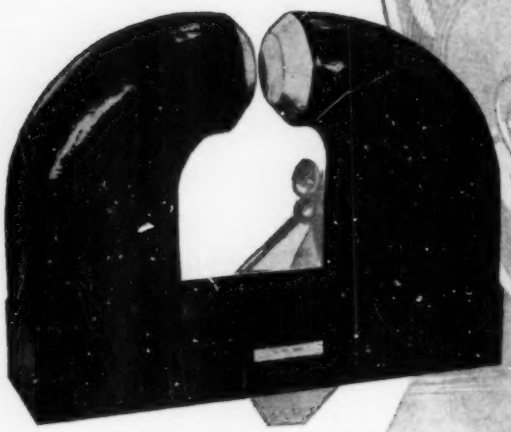
Street_____

City_____ Zone_____ State_____

Kodak TRADE-MARK

Largest Horn Type Permanent Magnet—

is an INDIANA HYFLUX ALNICO V



. . . weighing 350 pounds and developing a magnetic field of 8,000 gausses in a gap 1¼" long, this giant horn type permanent magnet was developed for one of the nation's leading university research laboratories. It is used in development work in the fields of nuclear physics, micro-wave research and polymerization.

Self-powered permanent magnets have long been preferred for thousands of applications in industry, electronics, communications and research . . . preferred because they are so compact, easy to install and produce uniform magnetic force without heat or moving parts.

Now, THE INDIANA STEEL PRODUCTS COMPANY, world's largest producer of permanent magnets, offers INDIANA HYFLUX Alnico V—the most powerful permanent magnet material commercially produced. Its 16% greater guaranteed energy product assists in developing new uses to swell the 30,000 existing applications for which THE INDIANA STEEL PRODUCTS COMPANY has furnished magnets.

From Design to Delivery . . . your production or design problem may easily—and economically—be solved with an efficient, powerful INDIANA HYFLUX magnet.

INDIANA'S engineers will cooperate fully—place at your disposal their vast experience at no cost to you.

NOW 16% MORE ENERGY for ALNICO V with INDIANA HYFLUX

. . . no extra cost—INDIANA HYFLUX Alnico V develops the highest energy product of any magnet material—an average of 5½ million BH max or more, with 5¼ million guaranteed! This means greater strength—yet HYFLUX costs no more than ordinary Alnico V. You, too, will want to join the swing to HYFLUX!

Let INDIANA'S designing and unified services save you time and money—and remember only INDIANA makes HYFLUX—the magnet material that at no extra cost gives you 16% more guaranteed energy for Alnico V.

Write or Phone Today! Ask for 11C catalog of stock experimental magnets.

INDIANA PERMANENT MAGNETS

THE INDIANA STEEL PRODUCTS COMPANY

VALPARAISO, INDIANA • • • Sales Offices Coast to Coast

SPECIALISTS IN "PACKAGED ENERGY" SINCE 1908

Regardless of . . .

1. Food Grinder Screw
2. Cylinder Head
3. Milling Cutter Body
4. Valve Seat
5. High Pressure Pump Body

SIZE, SHAPE, or WEIGHT

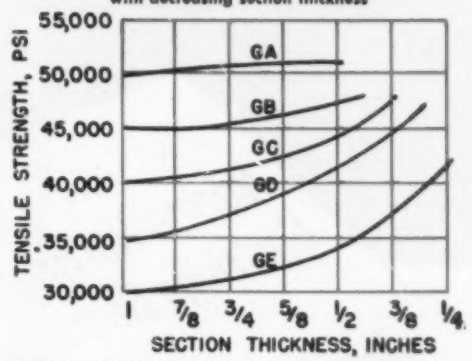
You can depend on MEEHANITE Engineering Properties!

The group of small lightweight Meehanite castings illustrated are typical of both the variety and importance of thousands of similar small casting specifications regularly met by many Meehanite foundries. While giant, heavy weight castings are spectacular and, of course, important too, many a vital component of important equipment lies hidden;—those small parts weighing from a few ounces to a few pounds yet whose properties and qualities must be both exact and uniformly superior.

Meehanite castings large or small are manufactured using definite and established process controls. These controls permit the regular meeting of property specification such as strength, hardness, modulus of elasticity or resistance to wear, heat and corrosion, according to the combination of characteristics required.

These same property controls aid in the ability to minimize mass influence as revealed in the chart shown.

Graph showing change in tensile strength with decreasing section thickness



WHEN YOU NEED "EXTRAS" IN QUALITY OR PROPERTIES
CONSULT ANY OF THE FOUNDRIES LISTED BELOW

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Canton, O.
Builders Iron Foundry	Providence, Rhode Island
Continental Gin Co.	Birmingham, Alabama
Crawford & Doherty Foundry Co.	Portland, Oregon
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Empire Pattern & Foundry Co.	Tulsa, Oklahoma
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Hardinge Company, Inc.	New York, N. Y.
Hardinge Manufacturing Co.	York, Pa.
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Lincoln Foundry Corp.	Los Angeles, California
E. Long Ltd.	Orillia, Ontario
Otis Elevator Co., Ltd.	Hamilton, Ontario
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

MEEHANITE® NEW ROCHELLE, N. Y.

You don't have to Wish for Efficiency

Bearing performance becomes a reality when you use the Norma-Hoffmann "Cartridge" Bearing in your products. This double-row width bearing has 100% greater grease capacity than conventional bearings. The highly efficient seals lock grease in . . . keep dirt out. Carefully factory-packed with Norma-Hoffmann's specially compounded grease assures high antifriction performance for years on end. These are but a few of the reasons why the Norma-Hoffmann "Cartridge" Bearing is *"America's No. 1 Sealed Bearing."*

Norma-Hoffmann

AMERICA'S NO. 1 SEALED BEARING

NORMA-HOFFMANN BEARINGS CORP.
Stamford, Connecticut

FIELD OFFICES: Chicago, Cleveland, Detroit, Dallas, Cincinnati, Los Angeles, San Francisco, Seattle

Buddy Boy Popcorn Dispenser, molded for Buddy Boy Popcorn Co., Elgin, Illinois

Skillful Molding Helps Popcorn Sales POP

Let this Buddy Boy hot Popcorn Dispenser show you how we can serve your plastic product interests best.

Size-wise this was a big job. In spite of its size, however, the dispenser demanded ultra fine precision in both engineering and molding. The transparent pieces, being both non-warping and unsupported, are identical and required a very close fit. The legs, made hollow and in 2 pieces, needed the same fit. Transparency, edge lighting depressed from inside, and the colorful, large one piece top provided the point-of-sale punch.

Let us take the same kind of sales-minded, sound engineering look at your plastic problems today. It's help without obligation on your part.

Write on your letterhead for the new Injection Molded and Extruded Plastics Catalog. Or, for detailed information about Cinch-Plasco piping, tubing and fittings, write for circulars containing data and illustrations.*
**Trademark Registered*

ELMER E. MILLS CORPORATION

INJECTION MOLDERS and EXTRUDERS of: Tenite, Lumarith, Plastacele, Ethocel, Lucite, Nylon, Flexigon, Polystyrene, Styron, Loalin, Vinylite, Geon, Flexene, Polyethylene, Corex, Fortizel, Cinch-Plasco*, Sterlo, and other Thermoplastic Materials

2930 NORTH ASHLAND AVENUE • CHICAGO 13, ILLINOIS

YES, 33 OUT OF 45
MAJOR* CLASS I RAILROADS
USE SKF JOURNAL BOXES

This reliance on SKF by an industry whose standards for reliability are so high is typical of SKF's acceptance by *all* industry. 7166

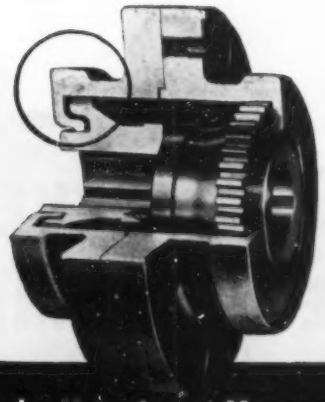
8 REASONS WHY SKF IS PREFERRED BY ALL INDUSTRY

integrity
craftsmanship
metallurgy
tolerance control
surface finish
product uniformity
engineering service
field service

SKF
BALL AND ROLLER BEARINGS

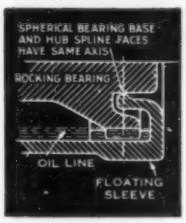
SKF INDUSTRIES, INC., PHILADELPHIA 32, PENNA.
-manufacturers of SKF *and* HESS-BRIGHT *Bearings.*

NEED "SPECIAL" COUPLINGS?



Koppers Can Help You Save Money With *Easily Modified*

STANDARD Fast's Couplings



FOOLPROOF DESIGN: Instead of perishable oil seals, Fast's use a permanent metal-to-metal closure. Oil is always maintained at a safe level, whether the Fast's is running or standing still!

LOWEST COST: Fast's Couplings cost less per year because they normally outlast the equipment they connect. Original cost can be divided by 20 years or more. As one user says: *"We've had this Fast's Coupling since 1930 . . . it's apparently going to last forever!"* (Name on request.)

NEW DEVELOPMENTS: Fast's were the first gear-type couplings on the market. And they're first again with new designs developed by Koppers—like the revolutionary new Breaking Pin Coupling now available.

IF YOUR coupling problem looks tough—specify Fast's. Then Koppers' engineers can go to work, study your problem, and in many cases find a special coupling is not needed at all. Instead, these coupling specialists can often modify a *standard* Fast's Coupling and save you important money!

Standard Fast's Couplings can be modified for hundreds of unusual applications. Records kept over the past 31 years prove that Fast's Couplings outlast the equipment they connect. Fast's still maintains its original design, without basic change or sacrifice in size or materials.

Don't take chances. Whether your application calls for special or standard couplings, specify Fast's. For full information and specifications, write for your copy of Fast's free catalog today!

KOPPERS

FAST'S

THE ORIGINAL GEAR-TYPE

Couplings

INDUSTRY'S STANDARD FOR 31 YEARS

Mail COUPON TODAY FOR FREE CATALOG!

KOPPERS CO., INC., *Fast's Coupling Dept.*, 239 Scott St., Baltimore 3, Md.

Gentlemen: Send me Fast's Catalog which gives detailed descriptions, engineering drawings, capacity tables and photographs.

Name.....

Company.....

Address.....

City.....Zone.....State.....

EVERY★JET ENGINE MANUFACTURER USES "AMERICAN WELDED" COMPONENT PARTS

★ United States

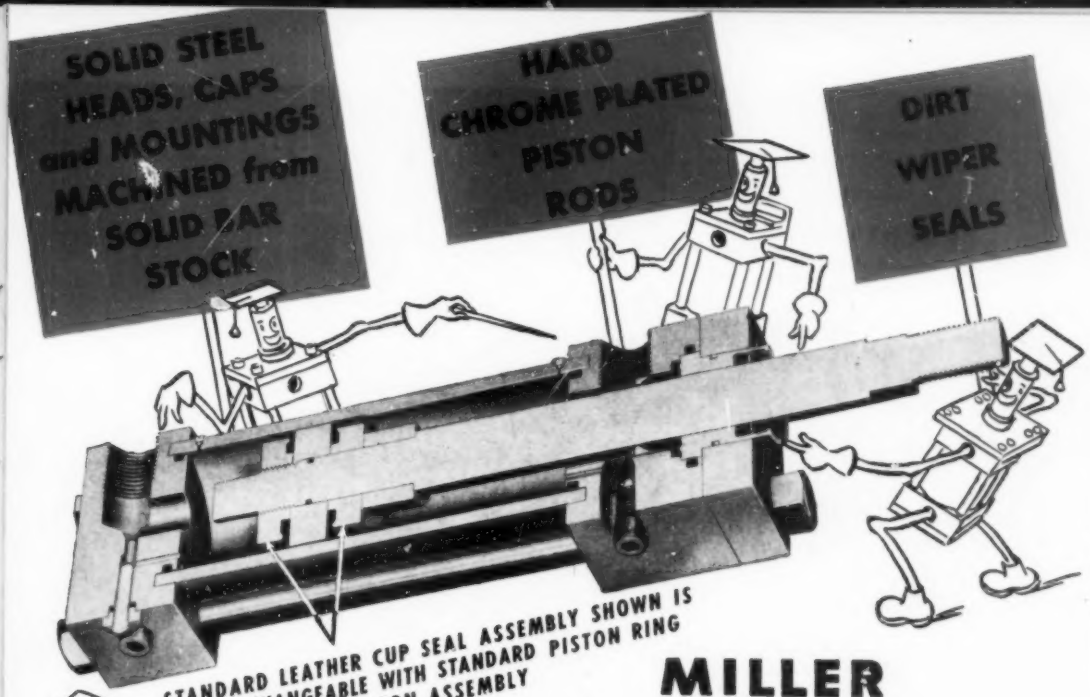
Welding is our business . . . 33 years' experience . . . complete designing, engineering and metallurgical service.

This is what we offer you if your requirements involve either fusion or resistance welding of either ferrous or non-ferrous metals.

Drop a line to our Product Development Division for our new illustrated catalog which will give you a look at our plant, facilities, and what we do.

THE AMERICAN WELDING AND MANUFACTURING COMPANY

140 DIETZ ROAD • WARREN, OHIO



STANDARD LEATHER CUP SEAL ASSEMBLY SHOWN IS INTERCHANGEABLE WITH STANDARD PISTON RING PISTON ASSEMBLY

MILLER *High Pressure* HYDRAULIC CYLINDERS

Meet J. I. C. HYDRAULIC STANDARDS

(Write for *FREE* copy of these "Standards")

Years before the Joint Industry Conference (J. I. C.) Standards for specifying "quality" hydraulic equipment were adopted, the *standard* design and construction features of Miller High Pressure Hydraulic (2000-3500 psi) Cylinders already included ALL the specifications for cylinders, seals and pistons now called for by the "Standards". Hard chrome plated, scratch-resistant piston rods and dirt wipers have long been standard Miller cylinder features yet are required by the "Standards" only under severe conditions.

Solid steel heads, caps and mountings which eliminate costly, dangerous breakage even under the severest operating conditions represent an "extra-quality" standard Miller cylinder feature which actually exceeds the high quality set by the J. I. C. Standards.

The Miller "Patented" Hydraulic Piston Rod Seal which has no manual adjustment and is automatically self-adjusting and wear-compensating to give life-long leakproof service without ever requiring any manual adjustment whatsoever . . . far surpasses the requirement of J. I. C. Standard H6.2.5 which specifies "Stuffing boxes for automatic packing shall be so designed as to prevent adjustment beyond the functional limits of the packing"

Benefits to You

No Broken Castings

No Scratch-Damage to Piston Rods, Bushings and Seals

NO COSTLY "DOWNTIME"

NO REPAIRS

NO MAINTENANCE

NO POWER WASTAGE

Write for illustrated cylinder bulletins A-105 and H-104

COMPLETE MILLER CYLINDER LINE INCLUDES: AIR CYLINDERS, 1½" to 20" BORES, 200 PSI OPERATION; LOW PRESSURE HYDRAULIC CYLINDERS, 1½" TO 6" BORES FOR 500 PSI OPERATION, 8" TO 14" BORES FOR 250 PSI; HIGH PRESSURE HYDRAULIC CYLINDERS, 1½" TO 12" BORES, 2000-3000 PSI OPERATION. ALL MOUNTING STYLES AVAILABLE.

MILLER MOTOR COMPANY

2002-04 N. HAWTHORNE - - - MELROSE PARK, ILL.

AIR AND HYDRAULIC CYLINDERS · ACCUMULATORS · COUNTERBALANCE CYLINDERS · [illegible]

CLEVELAND — PITTSBURGH — PHILADELPHIA — DETROIT — YOUNGSTOWN — BOSTON
HARTFORD — NEW YORK CITY — DAYTON — ST. PAUL — FORT WAYNE — INDIANAPOLIS
MILWAUKEE — NASHVILLE — SEATTLE — LOS ANGELES — SAN FRANCISCO — BALTIMORE
ST. LOUIS and OTHER AREAS.

Sales and Service from coast to coast

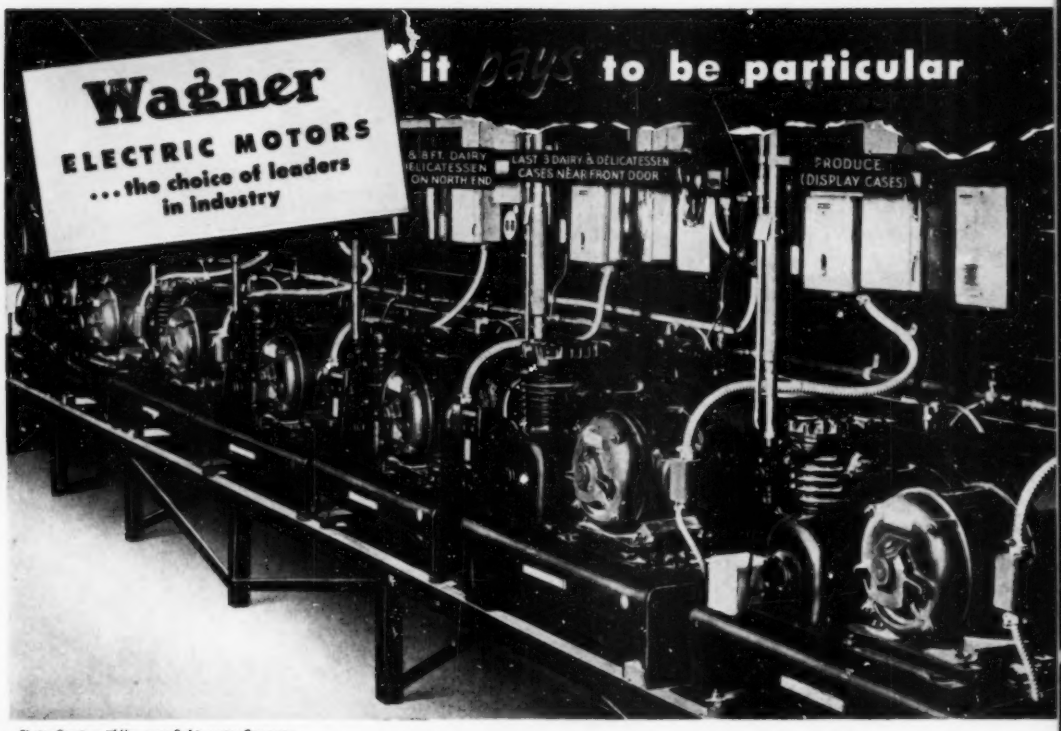

Wagner
ELECTRIC MOTORS
...the choice of leaders in industry
it pays to be particular
8 & 8 FT. DAIRY & DELICATESSEN ON NORTH END
LAST 3 DAIRY & DELICATESSEN CASES NEAR FRONT DOOR
PRODUCE (DISPLAY CASES)

Photo: Courtesy of Hussmann Refrigerator Company

you can count on

Wagner MOTORS

to furnish dependable power for your products

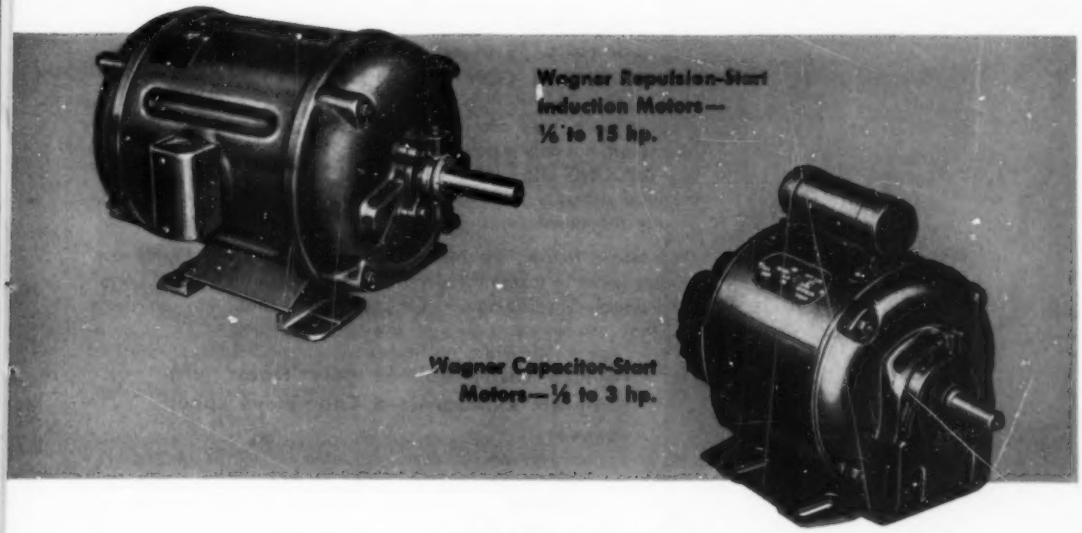
"A good motor is one I seldom hear about—and a good motor manufacturer is one who provides prompt honest service for the few motors I do hear about." These words, from the Service Manager of one of the large manufacturers who use thousands of Wagner Motors each year as standard equipment for their products, pretty well sum up the reasons why it will pay *you* to standardize on Wagner Motors. When you choose a Wagner Motor to power your product, you get uniform performance with exceptionally little trouble... you get a well-known name that adds a real selling point to your product ...and you get the advantage of a large nationwide service organization to promptly and efficiently repair the very few motors that require attention.

about your choice of motors...

Manufacturers of motor-driven appliances and equipment in every type of industry have chosen Wagner Quality Motors as standard equipment—both in their plants, and *on their products* because of their sound engineering . . . the proven precision in their manufacture . . . their uniformity of performance . . . and because they want to assure their customers of complete motor satisfaction. The wide range of types and sizes of Wagner Motors permits the selection of a trim, compact, standard motor to meet your exact needs. Bulletin MU-185 gives full information on the complete line of Wagner Motors. Thirty-one branches, in principal cities, are ready to assist you in any motor problem.

you'll save time, money, worry because:

1. Improved engineering features assure long life and efficient operation.
2. Wagner Motors are available in a wide range of types and sizes for every application.
3. Wagner Motors are backed by a liberal warranty.
4. They are available from Wagner Branches in all principal cities.
5. More than 650 Wagner Authorized Service Stations and Parts Distributors *plus* 25 Wagner-owned Service Branches provide on-the-spot service, replacement motors, or genuine repair parts.



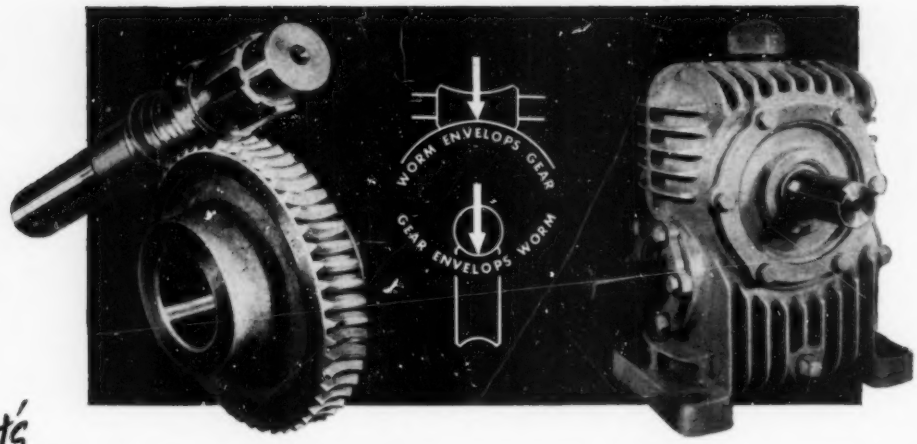
WAGNER ELECTRIC CORPORATION
6406 PLYMOUTH AVE. • ST. LOUIS 14, MO., U. S. A.

Wagner Electric Corporation 1891 1951

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS — AIR AND HYDRAULIC

BRANCHES IN 31 PRINCIPAL CITIES

A51-13



That's right—"hydraulically smooth" gears!

What we mean by "hydraulically smooth"

It used to be thought that carbide-tipped milling cutters on milling machines had to be protected against carbide-damaging gear vibrations in the cutter drive by using large flywheels at the cutter head. When Cone-Drive double-enveloping gears were tried, their 'hydraulic smoothness' made the flywheels unnecessary.

Never heard of gears that are hydraulically smooth? Then you should try Cone-Drive DOUBLE-ENVELOPING gearing: In Cone-Drive gears, the pinion or worm is wrapped around the gear and the gear is wrapped around the worm in such a manner that

regardless of number of teeth, gear size or ratio, ⅛ of all gear teeth are in CONTINUOUS CONTACT.

What is more, they are in continuous FULL DEPTH area contact. As a result, not only is power transmitted in a smooth uninterrupted flow AROUND THE CIRCUMFERENCE of the enveloped gear, but the load capacity for a gear set of any given center distance is greatly increased.

That means longer, trouble-free service, and the ability to use smaller gears to transmit a given load. As a matter of fact, Cone-Drive double-enveloping gears are so compact that many designers find they can simply

replace costly built-in gear trains with complete standardized Cone-Drive speed reducers

If you are looking for gears or reducers that will give you real hydraulic smoothness, greater load carrying capacity in a limited space, and a simpler gearing installation, fill in the coupon, attach to your company letterhead and mail it today.

CONE-DRIVE GEARS
DIVISION OF MICHIGAN TOOL CO.
7171 E. McNichols Rd.
Detroit 12, Mich.

Please send me without obligation further information on double-enveloping Cone-Drive Gears. We are particularly interested in the following:

Horsepower_____to_____

Ratio ____/1 to ____/1

Name_____

Title_____

(attach to company letterhead and mail)

CONE-DRIVE GEARS
Division, Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

HERE'S THE ULTIMATE IN

Controlled **AIR CYLINDER POWER**

• • •

The BELLOWS AIR MOTOR

Built-in Electrically-Controlled Directional Valve

•

Built-in Piston Rod Speed Controls

•

Requires only a Single Air Connection

Model illustrated — Electrically controlled BEM-5-40 2½" bore, 4" stroke air motor.

The Bellows Air Motor combines air cylinder, electrically controlled air-powered directional valve, and two independent piston speed controls all in one integral power unit . . . a unit that requires only a single air connection which can be made with flexible hose.

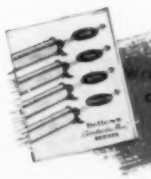
Here's compactness and flexibility to the N'th degree. The Bellows Air Motor makes designing for electrically-controlled air operation simple. No bulky power solenoids. No cumbersome, clumsy piping. No complex air circuits.

The unique Bellows ELECTROAIRE* valve gets away from bulk and weight by using the air-power itself to shift the valve, tiny built-in 8-volt solenoid controls to direct it. Makes the whole set-up safe from electrical hazard, safe to operator, safe to machine. The Electroaire valve will operate submerged, flooded with coolant, piled high with chips or dust. And the tiny solenoid control units are guaranteed against burnout!

Integral construction means *quick, responsive power, controlled power, safe power.* For any air cylinder operation the Bellows Air Motor offers maximum effectiveness, minimum over all cost.

*TM Reg. Patent Pending

1167-1



Write for your FREE copy of Bulletin CL-10. Address Dept. PE-951

The Bellows Co.

AKRON 9, OHIO

FIELD ENGINEER OFFICES IN ALL PRINCIPAL CITIES

Manufacturers of "Controlled-Air-Power" Devices, including conventio work feed tables, air-powered machine tool feeds, air-operat

SHENANGO Centrifugal CASTINGS ... KEY TO SAVINGS

These ram pistons, centrifugally cast of Meehanite Metal for 300-ton hydraulic press, must withstand 4,000 p.s.i. Completely machined and assembled by Shenango.

Teamed up for longer life under pressure

SHENANGO CENTRIFUGAL CASTINGS OF MEEHANITE METAL

FOR pressure service . . . for almost *any* severe service . . . it's hard to match Shenango *centrifugally* cast Meehanite Metal.

First, Shenango's centrifugal process means a uniform, high-strength, pressure-dense casting, free from sand inclusions, blow holes and other defects. Next, in Meehanite Metal you have finer graphite flakes, always more evenly dispersed, thus avoiding stress concentrations and permitting a finer finish.

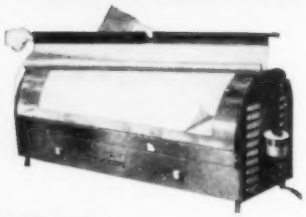
So here's a combination you just can't beat for wear-life . . . for resistance to abrasion, pressure or shock . . . for long-range *economy!*

If *your* plans call for essentially symmetrical parts, large or small, rough, semi- or finish-machined, check with Shenango. Get *all* the facts! Informative bulletins are yours for the asking.

SHENANGO-PENN MOLD COMPANY
Dover, Ohio
Executive Offices: Pittsburgh, Pa.

SHENANGO
ALL RED BRONZES · MANGANESE BRONZES · ALUMINUM BRONZES
MONEL METAL · NI-RESIST · MEEHANITE METAL

Fast, Efficient, Low-Cost
WHITEPRINTERS
for Plant, Lab, Office



SPEE-DEE
Saves up to 80% of Commercial Blue Print Costs!

● Quickly make accurate black-on-white or blue-on-white prints up to 24" x 36" from translucent originals, at less than 2c per sq. ft. Just plug into 115 volt a.c. line. Makes photo-copies too. Uses diazo (moist or ammonia dry) process. $155.81 includes initial supply of paper and developing powder. Printer only, $149.81. Shipping weight, 85 lbs. Smaller models from $55.12. *Order the Spee-Dee on 10-days free trial or write for full facts.*

MODEL "D" VERSA-LINER
Volume Production—Prints when Needed

● Economically prints and develops black line and colored line white-prints. Uses dry ammonia-fume diazo method. Plugs into standard 115 V 60 cycle a.c. line, using 19 amps. Easy to install and operate. Handles cut sheets or roll stock up to 42" wide in any length. Variable speed up to 5 ft. per min. New light source—low replacement cost. Easy to clean. Minimum maintenance. Complete, $1295. Moist diazo-type model at $1095. *Get full facts now.*

PECK & HARVEY
5745 N. WESTERN AVE., CHICAGO 45
Manufacturers of Whiteprint, Blueprint and Photocopy Equipment

ROTOR
Finished rotors are sprayed with a special rust inhibitor which covers the rotor, the shaft, and cadmium-plated fan used on smaller motor sizes. Larger motors have aluminum fans. These are not sprayed.
STEEL PARTS
The complete assembly of body and shell, with the stator, is dipped in "Robbinite," and this moisture-resisting undercoating—developed by Robbins & Myers—is then baked on, prior to final painting.
END-HEADS
Cast-iron end-heads and the cast-iron terminal box are carefully cleaned and given the same anti-corrosion treatment, inside and out, often specified by our Armed Forces for use in damp climates.

Now...

YOU GET "PACKAGED PROTECTION" IN R&M *ALL-WEATHER* MOTORS

SEALED AGAINST LEAKAGE

Terminal box is gasketed, and lead-ins are sealed at the motor shell. Repellent grease on shaft keeps moisture away from bearings. End-heads give motor full-height protection.

Standard R & M Integral Motors now are completely "Weatherized"—and all at *no extra cost to you*. They're protected—inside and out—from damaging moisture which so often causes premature failure. Weatherizing prevents rust, corrosion, and rapid deterioration of insulation materials. It makes good R & M Motors last even longer, *wherever* they're installed.

PROTECTION, PLUS. New R & M Weatherizing, plus R & M "Clean Sweep" high-velocity *end-to-end* ventilation, keeps these durable motors both internally clean and *remarkably* cool-running. They operate cooler than comparably rated motors on the same work. And you can even mount them outdoors *without a cover*. They're snake-proof and mouse-proof. Nothing has been forgotten.

VALUABLE "EXTRAS." Only Robbins & Myers gives you all these "extras" in a *standard* motor: Weatherizing . . . shrouded end-heads . . . pre-lubricated, sealed ball bearings (adopted in 1939) . . . insulation of *both* phase groups and coil windings . . . and many other construction refinements. Sizes: Polyphase, 1-50 h.p.; Single-Phase and D. C., 1-7½ h.p.; Totally Enclosed Fan-Cooled and Explosion-Proof, 1-40 h.p. Write for free Bulletin No. 400.

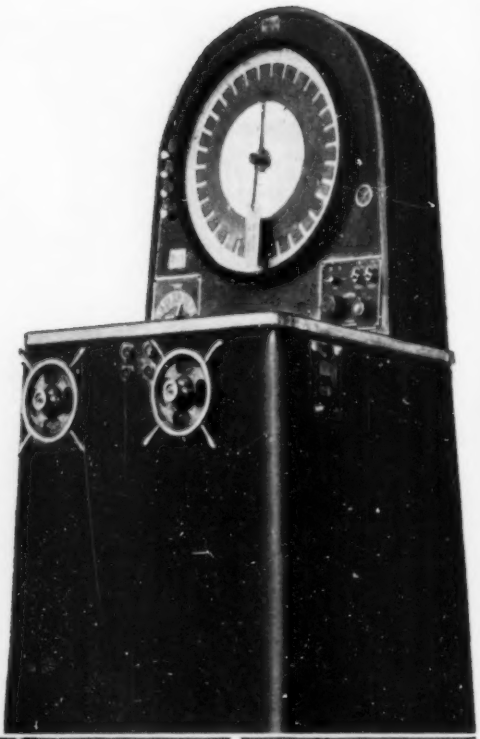
• *Robbins & Myers is big enough to serve your every need completely, yet not too big to serve you personally and promptly. For literature or gratis aid in solving powering problems, address Dept. P-91.*

ROBBINS & MYERS, INC. MOTOR DIVISION
Springfield 99, Ohio • Brantford, Ontario

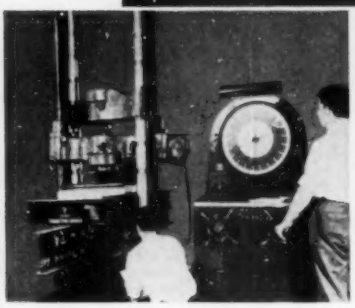
MOTORS • HOISTS • CRANES • FANS • MOYNO PUMPS • FOUNDED 1878

PITTSBURGH TESTING LABORATORY
ANALYSIS INSPECTION TESTING RESEARCH
ENGINEERS AND CHEMISTS

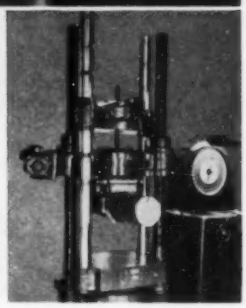
This Nation-wide
Testing Organization
Gets the Facts with
BALDWIN
TESTING EQUIPMENT



A 300,000 lb. B-T-E Universal Machine and Baldwin SR-4® strain gages team up for a traveling block and hook assembly test in Dallas.



Deflection test on light weight aggregate concrete pre-cast roof slab in a 200,000 lb. B-T-E machine at Pittsburgh headquarters.



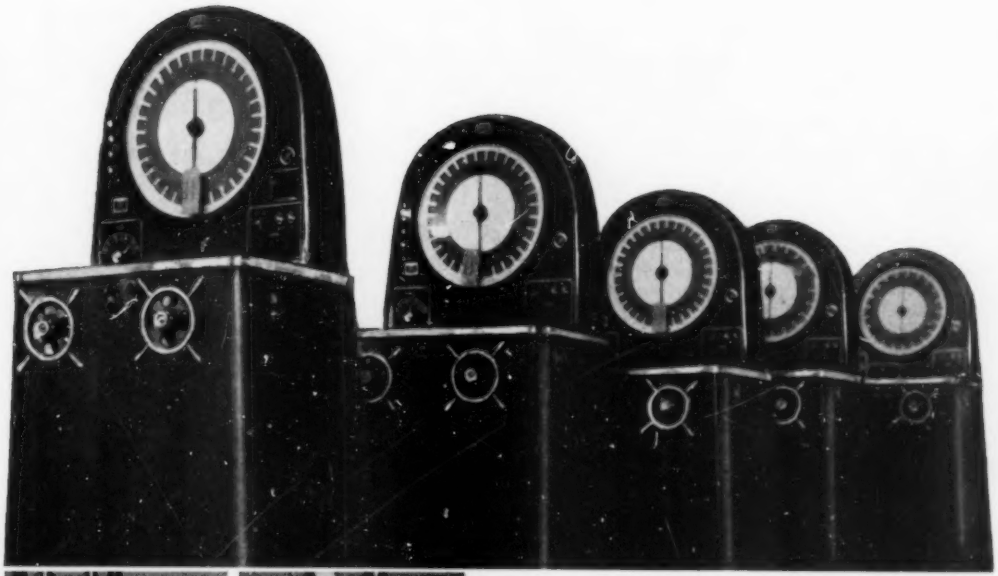
Testing a four-way strain band used for lumber on a 300,000 lb. B-T-E Machine in the P.T.L. San Francisco Branch.

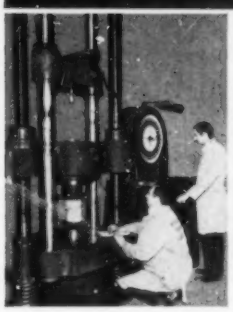
Eddystone Division
Baldwin-Lima-Hamilton Corp.
Philadelphia 42, Pa.

BALDWIN
BLH
LIMA-HAMILTON

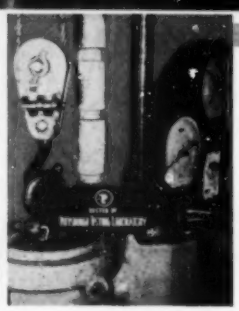
BALDWIN
TESTING
OFFICES IN PRINCIPAL CITIES

These six B-T-E Universal Testing Machines are part of a single order built for Pittsburgh Testing Laboratory.





Determining modulus of elasticity of concrete on a 300,000 lb. B-T-E Machine in the Buffalo Branch.



Here a 300,000 lb. B-T-E Machine in the Houston, Texas, Branch is testing a snatch block.

Because Industry recognizes the "high cost of ignorance" in design and construction, the Pittsburgh Testing Laboratory has built its fact-finding activities into one of the largest independent testing organizations in the country.

From its five-story headquarters in Pittsburgh, P.T.L. operates a chain of 23 industrial laboratories serving practically every important industrial center, and covering almost every field of testing and inspection.

Equipment includes scientific apparatus of the most modern types—with Baldwin testing equipment very well represented. Baldwin-Tate-Emery Universal testing machines of large capacity are installed in 13 branches. SR-4® gages and devices are extensively used, as are miscellaneous Baldwin accessories.

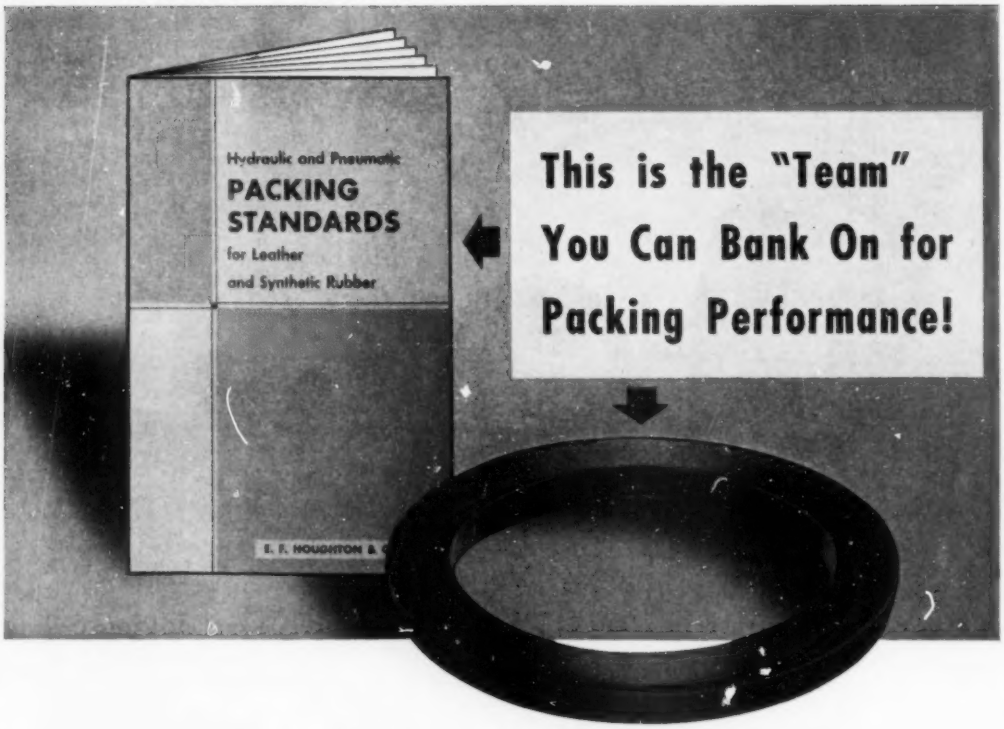
Whether you are setting up a small routine testing laboratory, or a full scale facility, you'll find a complete answer to your equipment needs in Baldwin's complete line. Write us your interest —we'll send literature.

-LIMA-HAMILTON

HEADQUARTERS

GENERAL OFFICES: PHILADELPHIA 42, PA.

In Canada: Peacock Bros., Ltd., Montreal, Quebec



HOUGHTON Quality + HOUGHTON Engineering

● Producing packings of uniform quality—and selling them, of course—is of prime importance to us. But we believe design engineers know us just as well for the completeness of Houghton Service. Together, Houghton quality and Houghton engineering produce a perfect "team" that will help make designing and specifying easier for you. Consult us freely about your hydraulic and pneumatic packing problems, without obligation. Meantime, we will gladly send you our "Packing Standards" booklet which received industry recognition for its influence in establishing packing standardization. Just write or call E. F. Houghton & Co., Philadelphia 33, Pa.

VIM LEATHER and VIX-SYN PACKINGS

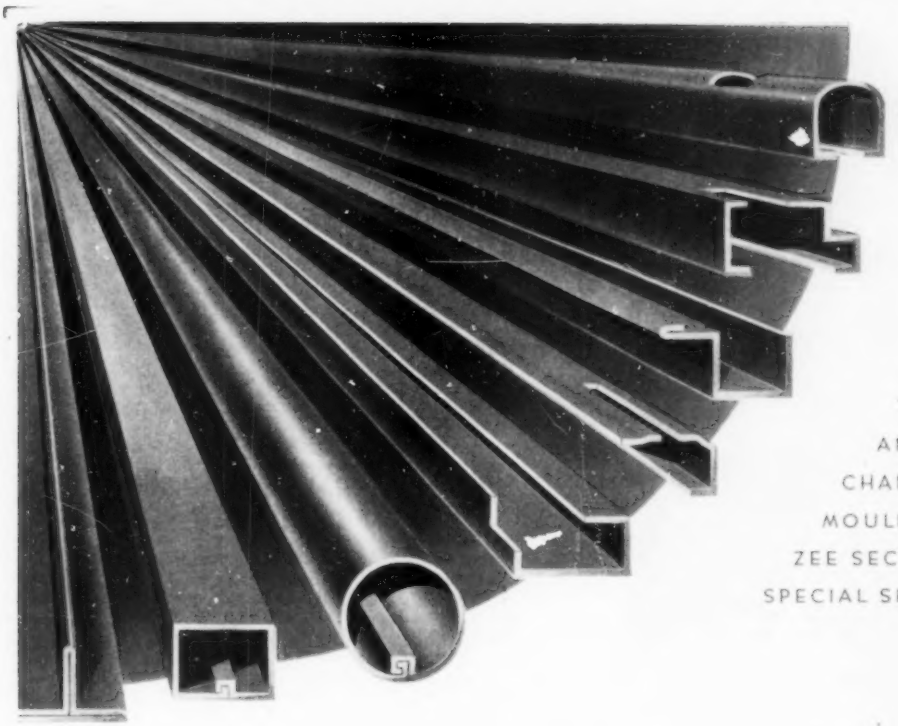
. . . products of

Write for latest edition of "Packing Standards" which has been accepted as standard by the industry.

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .



TEES
TUBES
ANGLES
CHANNELS
MOULDINGS
ZEE SECTIONS
SPECIAL SHAPES

faster production of finished roll formed parts

Manufacturing of equipment may be your business . . . fabricating of parts is ours. We're experts in our line and can help you meet your commitments faster—cheaper.

Roll Formed Products Company's special equipment speedily turns out pieces by the thousands—by the millions, if needed. By our rolling operation instead of break-forming, we roll, punch, notch and size each piece in one fast operation—to precision detail.

Roll Formed Products Company makes its own dies to assure uncompromising specification accuracy. Consult ROLL FORMED PRODUCTS COMPANY when placing subcontract Defense Orders. Write for brochure of our facilities.

ROLL FORMED PRODUCTS
COMPANY

MAIN OFFICE AND PLANT
3760 OAKWOOD AVE. · YOUNGSTOWN, OHIO

ON OLD OR NEW MACHINE TOOL OPERATIONS—

YOU CAN STEP UP YOUR PRODUCTION AS MUCH AS 30%

....WITH THIS SIMPLE, RUGGED, LOW COST AIR CYLINDER!

The pressure for production is on! Manufacturers everywhere find it increasingly difficult to keep pace with the demands of the day. But there is a way—a brand new way requiring no addition to manpower, no addition to plant facilities. The answer? Remarkable Bendix-Westinghouse Robotair Industrial Controls. With their wide range of applications, Robotair controls offer you amazing improvements in production speed and economy through increased productivity of man and machine at *unbelievably low initial cost.* Robotair units are available as original equipment for machinery manufacturers or for easy installation on shop equipment.

Send today for an informative booklet and find out how you can cut costs, speed production with Robotair! Address Bendix-Westinghouse Automotive Air Brake Co., Dept. A, Elyria, Ohio.

CHECK THESE FEATURES:

- ★ Frictionless
- ★ Leakproof
- ★ 100% efficient for total life
- ★ No oilers or filters needed
- ★ Holding pressures up to 5000 lbs.
- ★ Diaphragm has rolling action and exceptionally long life
- ★ Made from high grade steel stamping—all metal parts cadmium plated
- ★ Chrome Molybdenum Steel Push Rod heat-treated for maximum toughness
- ★ Easily installed

FOR HOLDING, CLAMPING, BENDING, SWEDGING, STAKING, RIVETING

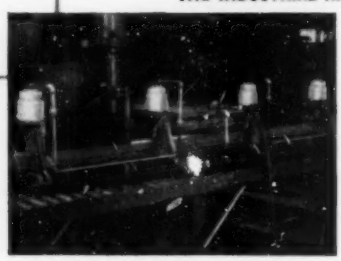
ROBOTAIR

THE INDUSTRIAL AIR CONTROL OF A THOUSAND USES

BENDIX-WESTINGHOUSE ROBOTAIR

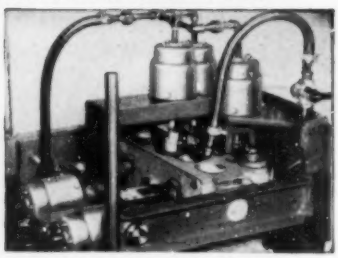
Bendix-Westinghouse

Bendix-Westinghouse Automotive Air Brake Company Elyria, Ohio



REDUCES OPERATOR FATIGUE

Four Rotochambers installed on the fixture in this spot welding operation replaced cumbersome hand clamps, saving time, greatly reducing operator fatigue.



SPEEDS INSPECTION METHODS

Installation of Rotochambers on this water test operation for engine castings eliminated hand operated fixtures, thereby speeding inspection and cutting costs.

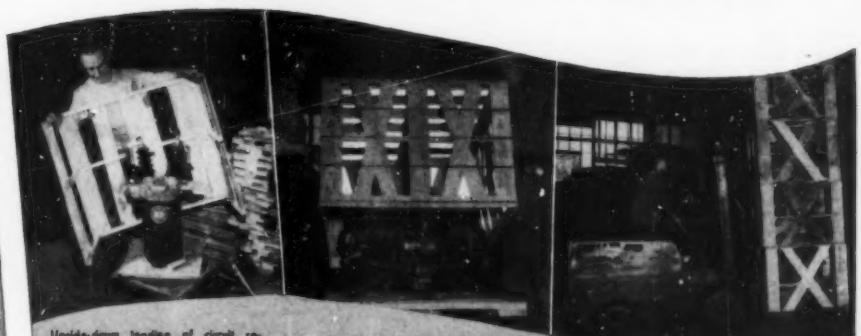
Now, more than ever before...

YOU NEED THE PROTECTION OF

WIREBOUND BOXES and CRATES

Losses due to container failure have no place in an industrial economy facing material allocations and shortages. That's why you should investigate *Wirebounds* —which combine the strength of steel with thinner wood to bring you *better product protection at lower cost.* Three hundred graduate engineers of the Wirebound Institute have been technically trained to design tailor-made *Wirebounds* which assure damage-free product delivery. The value of this container engineering is clearly demonstrated in the following case histories. We will be glad to show you how these benefits apply to *your* product. Use the coupon below.

YOU CAN CUT DAMAGE CLAIMS LIKE THIS:



Upside-down loading of circuit reclosers caused breakage, leakage, sometimes irreparable damage in handling and transit. Since switching to Wirebounds, company reports damage claims have become negligible.

Using Wirebounds designed to "float" 400 lb. precision engines, this manufacturer chalked up a record of 3000 shipments in fifteen months without a single instance of damage in transit due to container failure.

Flexible power saw makes reduced shipping weight from 820 to 775 pounds, cut crating time 30%. Company stacks and handles units four high. Shipping damage due to container failure has been completely eliminated.

choose your course of action...

Wirebound
BOXES & CRATES

☐ Send me general information . . . complete descriptive book titled "What to Expect from Wirebounds."

☐ Send me specific information . . . tear sheets of case histories of packing products similar to mine.

☐ Give me direct action send an Institute trained sales engineer to show the advantages of Wirebound packing for my own product.

NAME _____ POSITION _____

FIRM _____

STREET AND NUMBER _____

CITY _____ ZONE _____ STATE _____

OUR PRODUCT IS _____ IT WEIGHS _____

Users names on request

mail now to WIREBOUND BOX MANUFACTURERS ASSOC.
Room 1152—327 South LaSalle Street, Chicago 4, Illinois

DESIGN LEADERSHIP

Portion of a **10-station Baush machine** which performs a wide range of drilling, reaming and tapping operations on engine block. Square D panels automatically control entire operation in rapid-fire sequence.

SQUARE D MOTOR CONTROL

On the Job in One of the Country's Newest Automotive Engine Plants

In automotive and industrial plants throughout the country, SQUARE D MOTOR CONTROL is putting more and more machine tools of every type and size through their paces.

There are sound reasons for this growing Square D preference. Unusual completeness of line satisfies virtually any AC or DC application requirement. Standardized components, each designed to perform a specific control function, are physically proportioned to make up compact, attractive control panels. There is no wasted space—yet there is complete accessibility for speedy inspection and maintenance. Square D control is designed for machine tool service.

Engineered, Factory Assembled and Tested by D

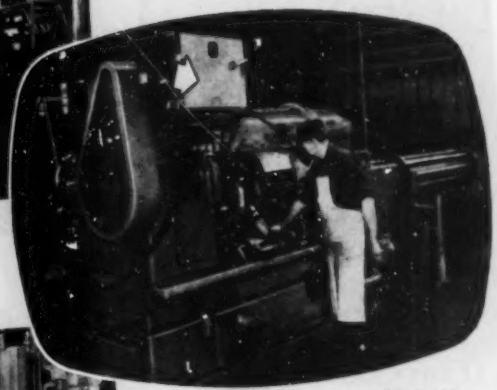
SQUARE D COMPANY

DETROIT MILWAUKEE LOS ANGELES

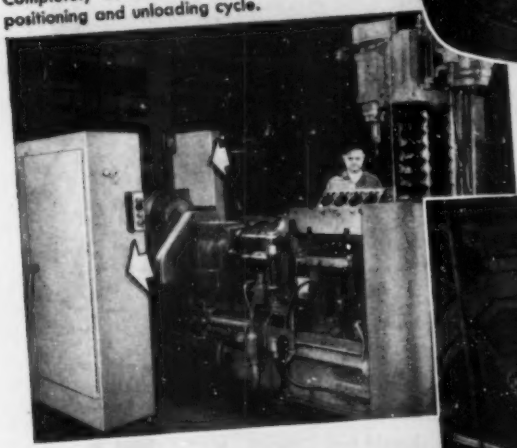
SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

IN ACTION!

at left **Square D controlled Snyder multiple tapping machine which taps holes for securing main bearings, oil pans.**



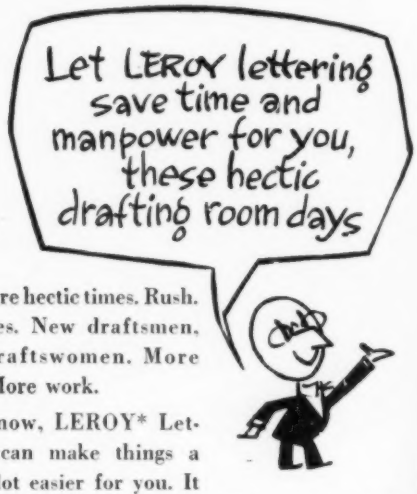
below **Simplex Stokerunit machine bores main bearings, cam shaft bearings, distributor shaft bearing and dowel holes. Completely automatic loading, boring, tool positioning and unloading cycle.**



above **Conomatic bar machine performs five operations on wrist pins—drilling, reaming, inside and outside chamfer and cut-off.**

above **Snyder Multi-head reamer finishes all valve guides.**

***Write* for Machine Tool Control Bulletin 207 describing Square D's complete line. Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.**



These are hectic times. Rush. Changes. New draftsmen, new draftswomen. More rush. More work.

You know, LEROY* Lettering can make things a whole lot easier for you. It takes almost no learning. Very little practice, and even the greenest draftsman can rattle it off like a blue streak, and as neatly as an old hand. One fellow can even carry right on without a break where the other left off.

THE MAN WHO HAND LETTERED THIS LINE

DID THIS WITH A LEROY LETTERING SET.

KEUFFEL & ESSER CO.
HOBOKEN, N. J.

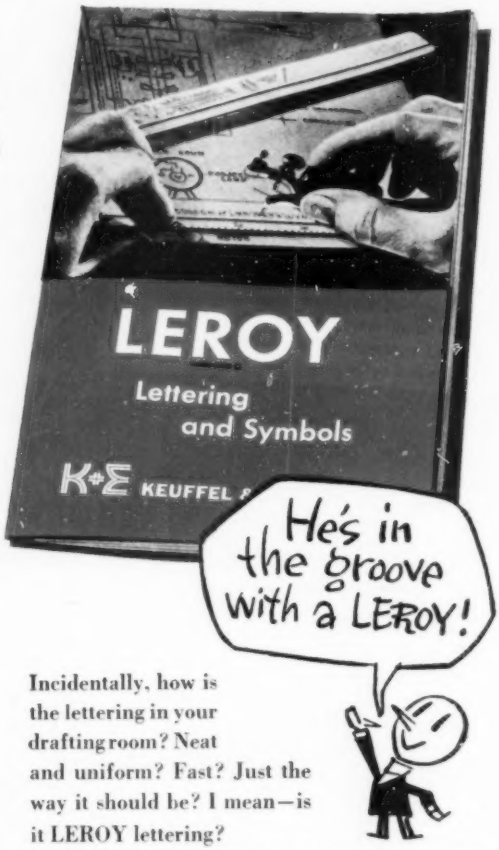
Please send me a free copy of your book about LEROY Lettering and Symbols Equipment.

Name_____

Firm_____

Street_____

City_____ Zone____ State_____



Incidentally, how is the lettering in your drafting room? Neat and uniform? Fast? Just the way it should be? I mean—is it LEROY lettering?

You can have LEROY alphabets and numerals in all sorts of sizes and styles—even in Greek, if you like. And LEROY symbols too, that save hours of work — electrical, welding, geological, mapping, mathematical—and all sorts of specials made to your own order.

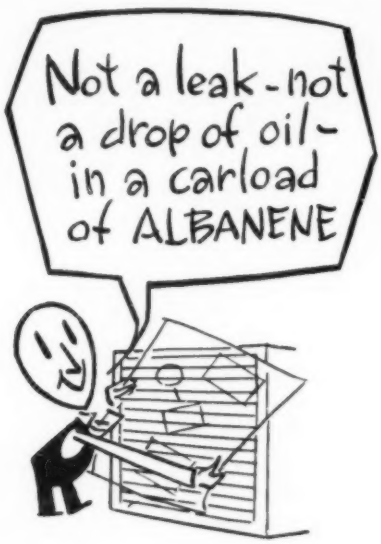
I can't begin to tell you in this one page. But send for the free LEROY Book. It will tell you a lot you may not know.

*Trade Mark ®

WHY ALBANENE* IS AMERICA'S No.1 TRACING PAPER

Do you know why ALBANENE holds up its record year after year as the No. 1 tracing paper on American drawing tables?

Can you remember back when K&E first put ALBANENE on the market years ago? It was the sensation of the drafting rooms. A paper transparentized without oils or wax. No more messy leaking. No spoiling of drawings in the files because the oil would run out from one to another.



No more loss of transparency and poor reproductions. No more aging, yellowing or turning brittle.

Yes, that was ALBANENE. Because ALBANENE was transparentized with something new and different, an inert, synthetic solid specially developed to do the job, a transparentizer that stayed put. The 100% long fiber, pure rag paper base was stabilized and transparentized through and

through. Drawings made on ALBANENE back in those days are still as clear and crisp, just as good for reproductions, as the day they were drawn.

*Trade Mark ®

And that is exactly how ALBANENE is still being made today. The same fine quality base stock. The same fine oil-free transparentizer. All the same top qualities.

That's why ALBANENE is America's No. 1 tracing paper.

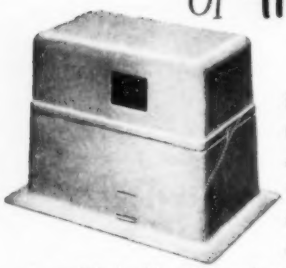
K+E
partners in creating
For 84 years K&E equipment and materials have been partners of the draftsman, engineer and scientist in shaping the modern world.

KEUFFEL & ESSER CO.

Drafting, Reproduction, Surveying Equipment and Materials. Slide Rules, Measuring Tapes

NEW YORK • HOBOKEN, N. J.
CHICAGO • ST. LOUIS • DETROIT • SAN FRANCISCO
LOS ANGELES • MONTREAL

The Tale of the Tougher Meter Housing



Rugged enough to take all the use—*or abuse*—you and the weather can give it, this attractive outdoor Meter Housing is molded with a Fiberglas† reinforcement.

Ten times lighter than the concrete unit it replaces, this housing protects costly utility meters and regulators from the ravages of weather, water, and soil corrosion . . . helps them give better service with less maintenance.

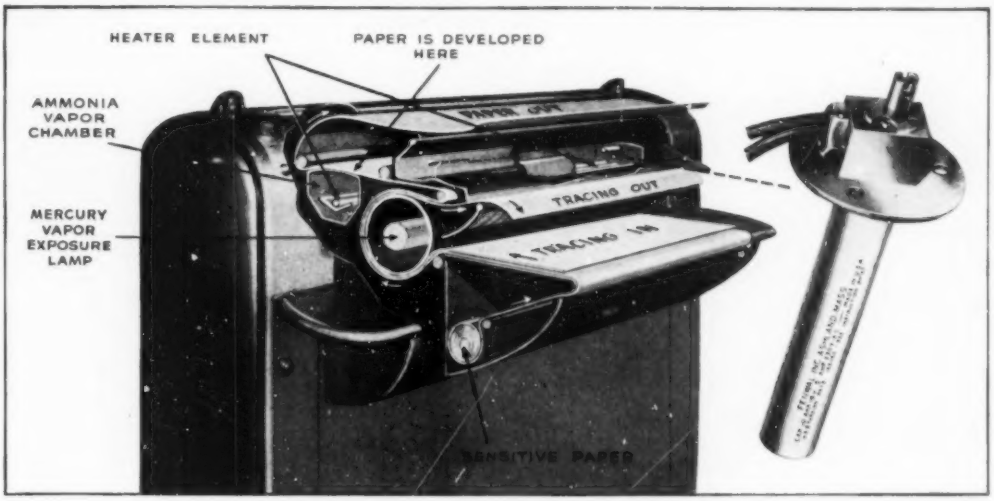
Zenith Plastics Co., Gardena, Cal., the molder, is just one of the many alert manufacturers who are making increasing use of Fiberglas-reinforced plastics to make a host of civilian and military products, such as washing machine parts, boats, fishing rods, aircraft components, and military instrument cases.

If you're looking for a unique new material that combines high strength, with light weight . . . that won't rot, rust, or absorb moisture . . . that is adaptable to volume production . . . then Fiberglas reinforcements are for you. Write today for details: Owens-Corning Fiberglas Corporation, Reinforced Plastics Division, Dept. 807, 16 East 56th Street, New York 22, N. Y.

*it's Plastic, reinforced with OWENS-CORNING FIBERGLAS Yarns

FIBERGLAS IS IN YOUR LIFE . . . FOR GOOD!

† Fiberglas is the trade-mark (Reg. U.S. Pat. Off.) of Owens-Corning Fiberglas Corporation for a variety of products made of or with fibrous glass.



Heat control problem in Ozalid reproduction machine solved

by Multi-Purpose Thermostat

When the Ozalid Streamliner reproduction machine was designed, a vital factor toward its successful performance was the maintenance of an even temperature within the developer tank.

After sensitive paper has been exposed, it is conveyed across the perforated top of the developer tank and developed by controlled aqua ammonia vapors. These vapors are superheated by a heater within the tank. Even heating at a specified temperature is imperative as, otherwise, uneven development results.

A low-cost THERMOSWITCH thermostat solves this heat control problem. It effectively maintains the vapor at a steady temperature for optimum developing conditions, by reacting both to vapor temperature and to radiant heat from the heater.

This application is but one of many types of control problems in which easy-to-install, easy-to-maintain Fenwal THERMOSWITCH thermostats have proved successful. Their activating control element is the single-metal shell that expands or contracts *instantaneously* with temperature changes, making or breaking the totally enclosed electrical contacts. Through this unique principle, THERMOSWITCH Units effectively control *many* variables where heat is a factor.

Find out now how Fenwal THERMOSWITCH Units can help you in *your* product. Mail coupon today.

Visit our Booth 206 at the National Instrument Exhibit, Houston, Texas

Fenwal

THERMOSWITCH®

The Precision, Multi-Purpose, Thermostat Control

SENSITIVE . . . *but only to heat*

FREE! **Get this bulletin . . . see what Fenwal THERMOSWITCH units can do for you.**
Just fill in coupon and mail . . . no obligation.

FENWAL, INCORPORATED, 29 Pleasant St., Ashland, Mass.
111 South Burlington Ave., Los Angeles 4, Cal.
TEMPERATURE CONTROL ENGINEERS

Name ..... Position .....
Company .....
Street .....
City ..... Zone ..... State .....

I am chiefly interested in the applications checked:

- ☐ Heating
- ☐ Cooling
- ☐ Humidity Control or Detection
- ☐ Alarm (over-temperature, under-temperature)
- ☐ Vapor Level Control
- ☐ Timing (thermal)
- ☐ Radiant Heat Control
- ☐ Pressure Control (by controlling vapor temperature)

OTHER (Please fill in your special requirements) .....
.....
.....

TEN TIMES THE LIFE AND STILL GOING STRONG!

Ni-Hard† Pipe Proves Superiority in Resisting Abrasive Action

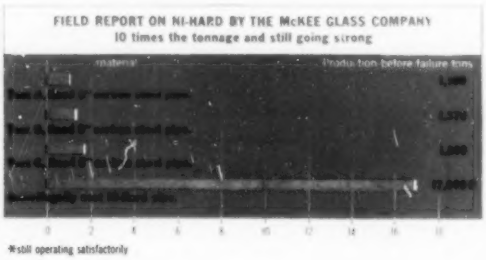
If your problem is abrasion, you'll be interested in this case history of Metal Mold centrifugally cast Ni-Hard pipe in action.

The McKee Glass Company, one of the nation's leading producers of molded glass for household and industry, uses a pneumatic conveyor system to handle its glass furnace charges. In this system tons of silica, sand, feldspar, borax, etc., are hurled at tornado-like speeds . . . about 100 miles per hour . . . through vacuum lines from boxcars to storage bins. Broken glass scrap (cullet) is added at the mixers to form a highly abrasive mixture.

Two years ago when the system was installed steel piping and later, lined steel piping was used. The severe abrasive action coupled with serious discoloration of the glass led to the search for a better conveying material. As a result, Metal Mold centrifugally cast plain end Ni-Hard pipe with a Brinell hardness of 600-650 was installed in the line's most abrasive sections.

The result, as reported by McKee, was more than satisfactory. Contamination was reduced 80%. Ni-Hard resisted abrasion much more effectively, as shown by the chart below . . . thus far, in fact, has carried *ten times the tonnage and the line is still going strong!*

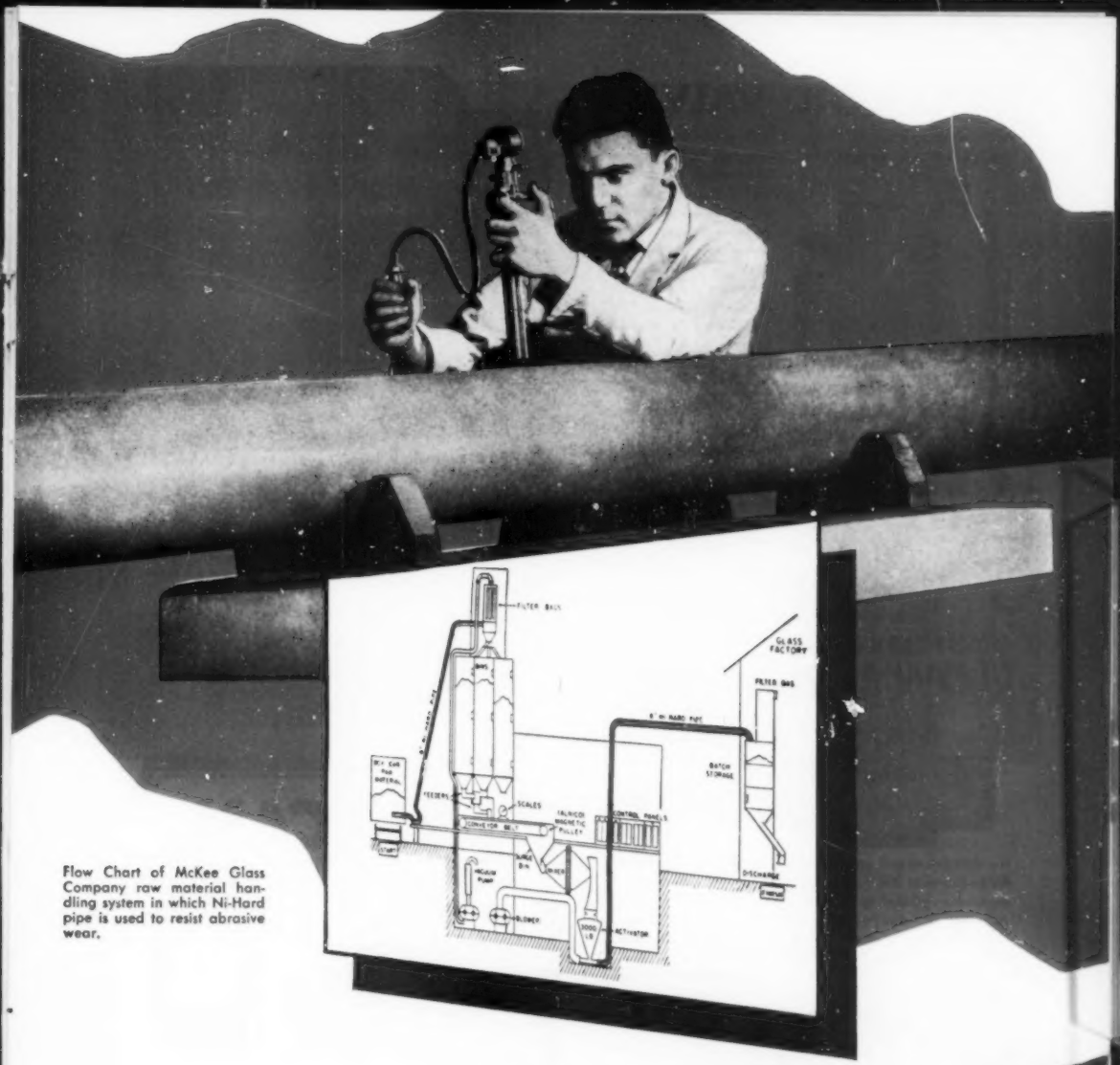
Today, the McKee Glass Company uses Ni-Hard exclusively in its conveying system. Their experience may suggest the answer to *your* abrasion problem.



*still operating satisfactorily

†Nickel-chromium white cast iron.
Ni-Hard is a registered trade name of The International Nickel Co., Inc.

U. S. PIPE AND
SPECIAL PRODUCTS DIVISION
AMERICA'S LARGEST PRODUCER OF CENTRIFUGALLY



Flow Chart of McKee Glass Company raw material handling system in which Ni-Hard pipe is used to resist abrasive wear.

TYPES OF METAL CAST

Stainless Steel—All AISI Types, plus special heat and corrosion resistant analyses.

Alloy Steel—all grades.

Carbon Steel—all grades.

Gray and Alloy Iron—all standard and special analyses, including Ni-Hard and Ni-Resist.

"Dual Metal"—Gray or alloy iron inside steel; gray iron inside chilled iron and tool steel; iron or steel inside stainless and many other metallurgically bonded two-metal centrifugally cast combinations.

SIZE RANGE

Outside diameters—2½" through 30". Wall Thickness—¼" to 4". Lengths—Up to 14'.

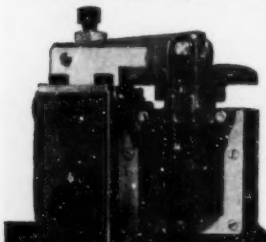
FOUNDRY CO.

BURLINGTON, N. J.

CAST FERROUS METAL PRODUCTS IN TUBULAR FORM

SOLENOID VALVES

have working pressures range as high as 3000 psi. They were specifically designed for remote push button control of hydraulic systems, as well as for the handling of any non-corrosive fluids. The poppet construction eliminates leakage. The impregnated coils are oil and moisture resistant. The unit can be mounted in any position.



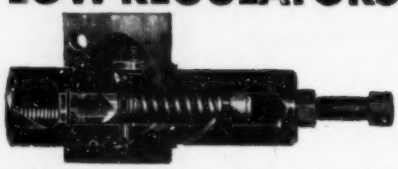
PRODUCTS OF

Waterman

ENGINEERING COMPANY

725 CUSTER AVENUE
EVANSTON, ILLINOIS

ADJUSTABLE FLOW REGULATORS



for cylinder speed control over a 50% range are built for pressures to 3000 psi. Model 320 shown meets requirements for cylinder speed adjustment yet maintains constant speed regardless of work or pressure fluctuations. There are types for Machine Tools—Earth Moving, Material Handling and Farm Equipment—Packaging Machinery—Steel and Paper Mills—Refineries—Oil Fields and Printing Presses.

MICRONIC LINE FILTERS

are made in pressures to 3000 psi for air, oil, water and other fluids. They are compact permitting more simplified design, have built-in durability, and are easy to clean. The Micronic element filters to 40 Microns providing full protection for pumps, valves and cylinders. The elements which are low in cost are easily replaced. They make possible maximum flow with a minimum pressure drop.

WRITE FOR OUR ENGINEERING COOPERATION AND FURTHER DETAILS

PRECISION
MOLDED RUBBER PRODUCTS
sponge • synthetic
solid rubber
Manufactured to your Specifications

For those "DO" orders of yours that require molded rubber products as an integral part of your equipment, you'll find that our past experience in manufacturing molded parts to specifications will be helpful to you. Send in your blueprints and let us give you an estimate on this type of work.

DUTCH BRAND

VAN CLEEF BROS. INC.
Manufacturers Rubber Products Est. 1910
CHICAGO 19, U. S. A.

VULCAN

WATER IMMERSION HEATER

Automatic
Thermostat Control
Heats
Water
Electrically

in large and small tanks, range boilers, etc.

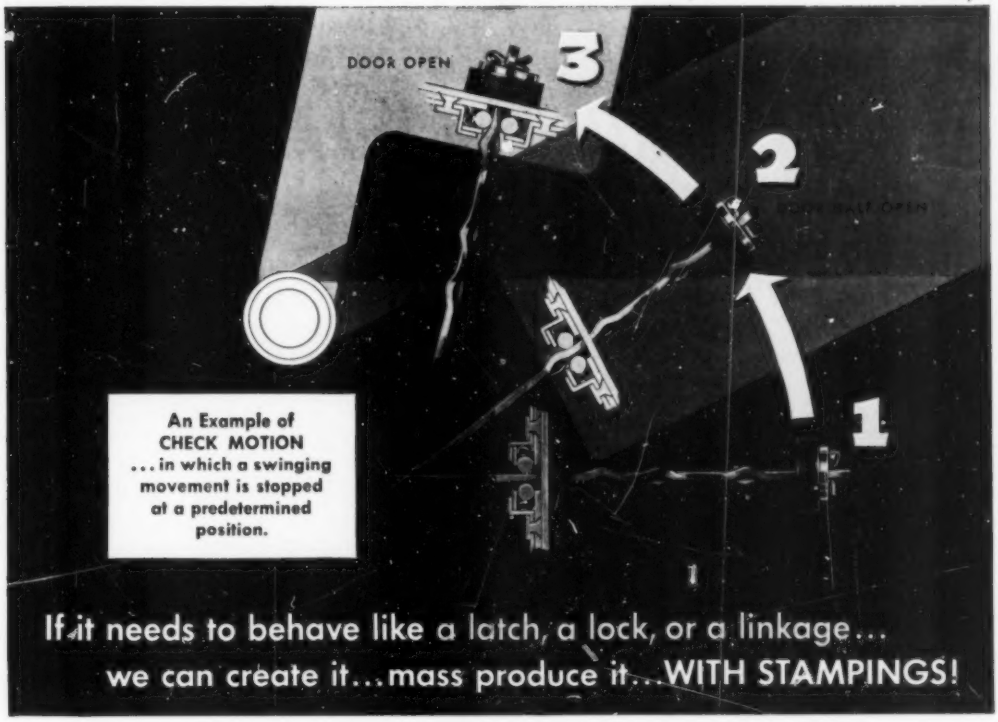
Provides low cost hot water for small factories and stores, offices, laboratories, apartments, barber shops, garage: trailers, summer camps, beauty shops, churches, clubs, dentists, farms, florists, lodges, markets, museums, photographic studios, etc.

EASILY INSTALLED
DOES NOT DISTURB EXISTING PIPING

Special types for heating oils, chemicals and other liquids.

VULCAN ELECTRIC COMPANY
DANVERS 18, MASS.

Makers of Vulcan Electric Soldering Tools, Electric Solder Pots, Electric Glue Pots, Electric Branding Irons and Electric Heating Units.



What kind of a motion device is required in *your* product? Does it need to latch, lock, catch or trip? Must it slide, swing or rotate? Should it operate by a spring, a cam, a lever or a pedal?

Our specialty is designing such devices to perform in almost any manner the job requires. And when it comes to manufacturing, we mass produce them by *stamping*—to unusually close tolerances. And we can keep the price surprisingly low.

Perhaps this design experience and specialized manufacturing approach suggest new possibilities for improving the safety, performance or salability of your product. If so, our engineers would like to discuss these possibilities with you. Or write for a copy of our booklet, "We Make Motions", which further explains our facilities.

THE REID DIVISION OF *The Standard Products Co.*

THE MARK OF A SUPERIOR PRODUCT

DEPT. D, GENERAL OFFICES: 2130 WEST 110 STREET • CLEVELAND 2, OHIO

WE MAKE MOTIONS

Take a whale of a bite out of product costs!

V-Belts by

put teeth in your power drives with DAYTON COG-BELTS*

DELIVER 40% MORE H.P.

SAVE UP TO 28% DRIVE-WEIGHT

SAVE UP TO 47% DRIVE-SPACE

The patented premium Dayton Cog-Belt (with rayon cords) will improve the performance of your product while lowering its cost. Here's why:

Cog-Belts deliver 40% more h.p. than ordinary V-Belts of the same size. 5 Cogs do the job of 7 ordinary belts. You save the cost of two belts, and two grooves per pulley. And your drive weighs 28% less, takes up 47.2% less room. You save on original cost, on shipping, handling, warehousing.

And here's the secret of the Cog-Belt's better performance. Cog-Belts are built to bend, like your finger, to take up compression strains without distortion as the belts go round the pulleys. Results: less strain, less heat, less stretch, less maintenance, longer life, less down-time.

You can add these premium features to your product! See the Dayton salesman; or write for latest engineering data on the Cog-Belt.

*T.M.

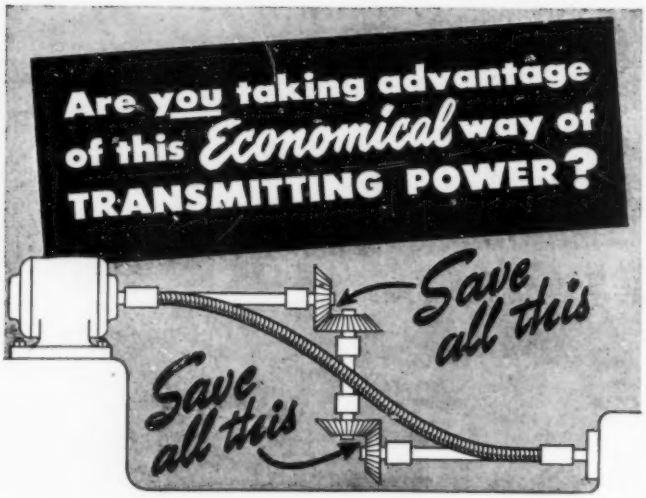
DAYTON RUBBER COMPANY • DAYTON 1, OHIO

THIS MEANS **OK**

THIS MEANS **COG** THE HIGH-SIGN OF BETTER POWER TRANSMISSION

Dayton Rubber

WORLD'S LARGEST MANUFACTURER OF V-BELTS



S.S. WHITE *FLEXIBLE SHAFTS*

save parts and cut assembly time and costs

THE illustration above speaks for itself when it comes to demonstrating the advantages of an S.S.White flexible shaft power drive. With one of these shafts, power can be taken from one point and delivered to any other point as simply and as economically as it could possibly be done.

The resulting advantages are most important in any design work—fewer parts, easier assembly, faster production, lower costs. They make it worth while considering S.S.White flexible shafts whenever you have a power transmission problem.

A large selection of sizes and characteristics suit S.S.White flexible shafts to a wide range of drive requirements. For details on these versatile, dependable mechanical elements,

S.S.White MAKES IT RIGHT

WRITE FOR NEW BULLETIN 3008

It contains the latest information and data on flexible shafts and their application. Write for a copy today.

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
Dept. D, 10 East 40th St.
NEW YORK 16, N. Y.

WESTERN DISTRICT OFFICE: Times Building, Long Beach, California

PRECISION MADE
Pheoll
SCREWS, BOLTS, NUTS and SPECIAL FASTENERS

save assembly time
improve product strength
and final appearance

ACCURATE THREADING SAVES TIME

Pheoll Screws, Bolts, and Nuts are easier to start, easier to drive and easier to tighten—because they're accurately machined and threaded. These features cut your assembly time and cost.

COLD ROLLED THREADING ADDS STRENGTH

The grain structure and flow of metal obtained through cold heading and roll threading increases the structural strength of Pheoll Fasteners. Cold working improves thread bearing surfaces, providing greater area of contact for firmer grip. Greater strength reduces possibility of shearing, and time lost in subsequent removal and retapping.

OUR INSPECTION IMPARTS YOUR PRODUCT APPEARANCE

Step by step Pheoll inspection, through every process of production, assures uniform head size and shape; cleanly milled and recessed heads, neat chamfering and countersinking. All these factors contribute to the quality and finish which add materially to your product's final appearance. *Write* for Pheoll's product literature and price list.

THESE PHEOLL PRODUCTS INCREASE YOUR PRODUCTION RATE. Thumb Screws Machine Screws† • Wood Screws† • Sheet Metal Screws† • Stove Bolts† • Rolled Threaded Wires and Studs • Special Rivets and Pins • Brass Washers

†Furnished in slotted and Phillips Recessed Head Types

Pheoll MANUFACTURING COMPANY
5700 ROOSEVELT ROAD
CHICAGO 50, ILLINOIS
SCREWS • BOLTS • NUTS

JOHNSON SLEEVE BEARING DATA

Bearing DESIGN

BRONZE SLEEVE BEARING DATA

Standard Tests for Sleeve Bearings-2

AS pointed out in the preceding data sheet—"Standard Tests-1"—the prime reason for the large number of tests employed is simply to assure the user that he is getting the greatest bearing performance possible for his money. This is necessary in Sleeve Bearings not only because there are so many types of bearings available but also because it is possible to so design any type to secure all the necessary properties. Cast bronze is a good example. There are approximately one hundred separate and distinct alloys from which to choose. If plasticity and/or embeddability is a chief requirement the usual method is to increase the lead content. If greater hardness is required, the lead content is lowered, then tin, or nickel, or manganese, for instance, is increased.

One of the chief points to remember in specifying sleeve bearings is that they can be "tailor-made" to suit practically any application. The only requirement is that we first determine all of the pertinent operating factors.

Resistance to Fatigue

This is the ability of the bearing material to withstand shocks and loads without deterioration or fracture. It is particularly valuable in testing bearings for internal combustion engines with rapidly alternating stresses on bimetal bearings such as steel backed, babbitt or bronze lined.

Izod Notch Toughness

This determines the amount of energy in foot pounds required to break a specimen. The specimen is notched and the energy required to fracture in a single blow indicates the toughness.

Johnson Bronze Alloy No.	PHYSICAL PROPERTIES			
	(1) Wear Rate (dry)	(2) Coefficient of Friction (dry)	(3) Izod Notch Toughness	(4) Resistance to Pounding
19	0.24	0.16	3.4	54
25	0.36	0.14	5.2	22
27	0.32	0.19	4.4	63
29	0.35	0.16	5.6	40
51	0.63	0.25	8.3	81
53	0.62	0.26	8.5	86
55	0.53	0.29	3.9	109
66	0.50	0.19	8.4	20
71	0.64	0.18	12.1	20
72	0.41	0.19	8.6	38

A typical listing and comparison of various popular, cast bronze bearing alloys.

Resistance to Wear

This test determines the physical ability to resist destruction of two surfaces rubbing together without lubrication. The results are usually tabulated in the loss of weight in grams per 10,000 revolutions.

Resistance to Pounding

This is determined by establishing the number of blows of a hammer weighing 7.5 pounds, falling 2 inches, are required to deform the specimen 5%.

Coefficient of Friction

This test in bearing material is always computed on a "dry" basis, or a set up in which no lubricant of any kind is used. It is usually determined on an Amsler wear test machine.

Thermal-Conductivity

Thermal-conductivity is the ability of a bearing or bearing material to dissipate heat. It is a determination of the B.T.U.'s, per unit of time that will move through the material.

•

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

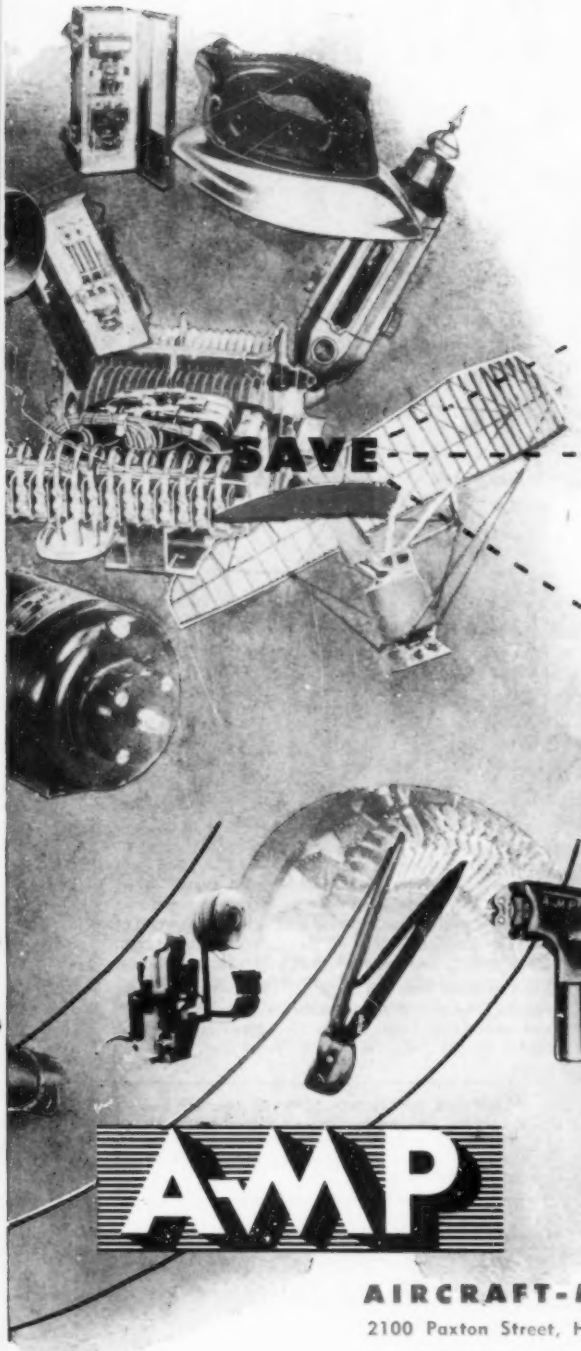
•

This bearing sheet data is but one of a series. You can get the complete set by writing to—

Johnson Bronze

SLEEVE BEARING HEADQUARTERS
508 S. MILL ST. • NEW CASTLE, PENNA.

WIRE TERMINATIONS
AT THE LOWEST POSSIBLE
INSTALLED COST . . .
AMP
SOLDERLESS
TERMINALS
AMP PRE-INSULATED DIAMOND* GRIP Solderless Terminal. U. S. Patent Nos. 2,410,321; 2,379,567; 2,205,111; 2,468,169. Other U. S. Patents Pending.
AMP SOLISTRAND* Terminal. U. S. Patents Pending.
*Trade-Mark
AMP Trade-Mark Reg. U. S. Pat. Off.



time

Eliminate tedious or old fashioned wiring methods. AMP wire terminations are accomplished quicker, better, and surer in but a fraction of the time required to solder, wrap, or insulate a connection. One stroke of a tool is all that is needed!

labor

AMP terminals are easier for workers to apply—tools are more convenient to use. Job time becomes productive time. Inspection is simpler. Special ratchet devices on tools prevent jaws from opening unless a complete crimp has been performed.

material

AMP PRE-INSULATED DIAMOND GRIP* TERMINAL (shown above left) is already equipped with body insulation. No tape, tubing, or separate insulation sleeving needed. No fluxes, soldering irons, tips, or heaters involved.

AIRCRAFT-MARINE PRODUCTS INC.

2100 Paxton Street, Harrisburg, 4, Pennsylvania

Canadian Representative: R. M. HUTCHESON, 10 Nordale Crescent, Nordington, P.O., Toronto 15, Ont., Canada, Elgin 5647

Only PARKER offers you

10 Years' Experience

in solving problems in cold drawing and cold extrusion

Use of Bonderite to improve difficult drawing began 10 years ago, established a new and accepted technique. In laboratories and mills Parker research and field engineers worked with manufacturers to perfect this method. Parker's affiliate in Germany,* leader in development of the technique in Europe, has constantly added its knowledge and experience.

Every year, and every installation, has contributed to Parker knowledge and practical experience — and recognition as authorities in this field of metal treatment.

90% of all cold drawn seamless steel tubing is treated with Bonderite as an aid in drawing.

*Metallgesellshaft, Frankfurt

Advantages of Bonderite in cold drawing and cold extrusion are many and worthwhile: Faster drawing; heavier reductions; longer tool life; reduced metal-to-metal contact; reduced galling and wear because Bonderite acts as an anti-flux; less scrap; fewer rejects, and greater over-all operating economy.

Do you have cold drawing or cold extrusion problems? Take advantage of the 10 years' knowledge and successful heavy-production experience of the leader in the field! Write or phone Parker today!

COMPLETE DRAWING SERVICE—Parker has everything you need—cleaners, rinses, Bonderite, and lubricants—all of them keyed to superior cold forming. Plus expert engineering guidance. Write for full information.

Bonderite, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

PARKER

Parker Rust Proof Company

2179 East Milwaukee Avenue, Detroit 11, Michigan

BONDERITE—Corrosion Resistant Paint Base • PARCO COMPOUND—Rust Resistant • PARCO LUBRITE—Wear Resistant for Friction Surfaces

RELIANCE *Engineering*

IN MOTOR-DRIVES GIVES YOU

Top Speed Production!

For almost half a century, Reliance Application Engineering in the field of motor drives and associated controls and regulators has served every industry. Today, electric drives engineered by Reliance are providing the fullest operating flexibility required to realize top speed production at lowest possible cost from all types of machines in all types of processing and converting. In this great diversity of successful applications of drives engineered by Reliance there is tangible, working evidence of the wealth of specialized experience and production "know how" which Reliance engineers are ready to place at *your* disposal. Just call or write the nearest Reliance office. Sales representatives in principal cities.

See three typical examples on the reverse side of this page

RELIANCE ELECTRIC AND ENGINEERING CO.

1080 IVANHOE ROAD • CLEVELAND 10, OHIO

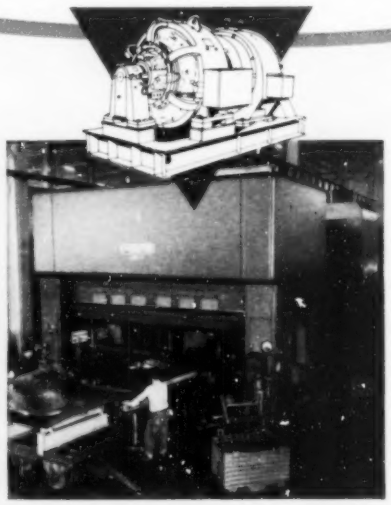
CANADIAN DIVISION: WELLAND, ONTARIO

RELIANCE ELECTRIC AND ENGINEERING COMPANY

Today, after almost 50 years of steady Reliance growth, the two words "AND ENGINEERING" continue to represent specialized engineering services in the application of electric motor-drives to help users achieve the greatest possible production from machines—at the lowest possible cost. Recent examples of typical results when Reliance engineering is applied to specific problems include these interesting applications . . .

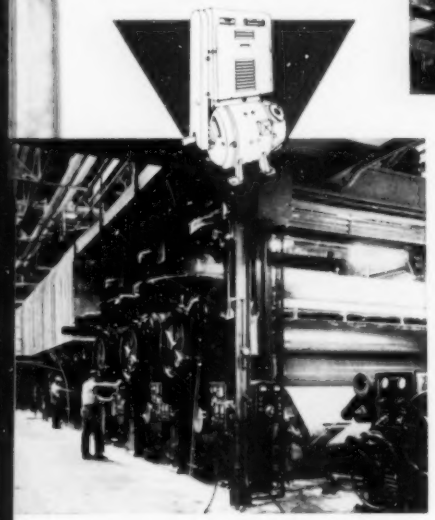
A Paper-Making "First"

First to make and finish paper in one continuous operation, this 154" paper machine at the New York and Pennsylvania Company also applies coating and does the supercalendering. Maintenance of dependable, precise speed relationships between all sections is absolutely essential. It is provided by a Reliance Sectional Paper Machine Drive coordinated by Reliance Section Interlock Regulators (SIR). Here is the simplest, most practical and most economical answer to specialized job requirements—furnished by Reliance Application Engineering.



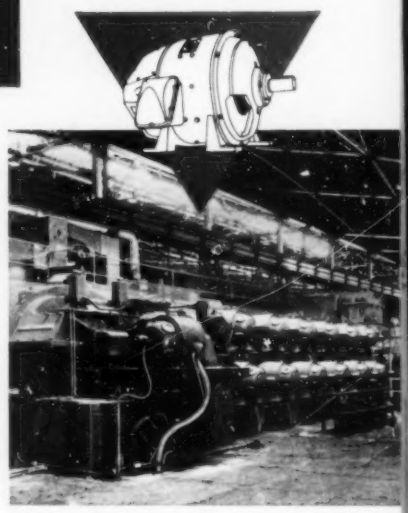
Synchronized Speed

1,000 foot-per-minute peak operating speed makes this new Fretz-Moon Pipe Mill, of the Wheeling Steel Corporation, Benwood, W. Va., the fastest ever built. Such tremendous speed posed a knotty problem in extremely close synchronization between speed of motors driving forming mill and motors driving carriage of flying saw. Reliance application engineers, in close cooperation with the equipment manufacturer, supplied the completely satisfactory answer by the use of Heavy Duty Type 'T' D-c. Motors, Electronic VSR Speed Regulators and M-G Sets.



World's fastest triple-action presses . . . with a big assist from their 500 hp. Adjustable-voltage Drives specially designed and engineered by Reliance! And in the application of drive motors on these huge body presses in the Ford Motor Company's new Buffalo Stamping Plant, electronic controls developed by Reliance research have accomplished other amazing things. These include the saving in production of a substantial amount of steel which was formerly scrapped and reduction of die replacements costs. Reliance M-G Sets power the drive motors in this application which offers abundant proof that soundly-engineered motor-drive is more than power.

World's Fastest

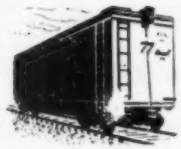


RELIANCE ELECTRIC AND ENGINEERING CO.

1080 Ivanhoe Road, Cleveland 10, Ohio • *Sales Representatives in Principal Cities*

CANADIAN DIVISION: WELLAND, ONTARIO

LARGE PANEL SIZE



Over 100,000 Railroad Cars Have Plywood Siding and Lining

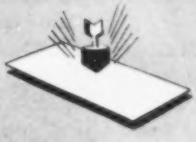
EASY TO WORK

Plywood Simplifies Pattern Work; Offers Design Adaptability

Low-Cost Plywood Bins Are Easy To Build, Give Long Service

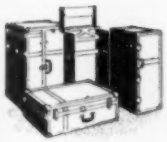
LIGHT WEIGHT

Re-Usable Plywood Concrete Forms Speed Work, Lower Job Costs

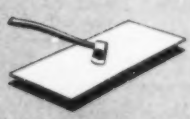


PUNCTURE-PROOF

GREAT STRENGTH



Plywood Boxes for Luggage Lend Strength, Light Weight

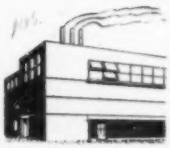


SPLITPROOF

Long-lived Plywood Shipping Cases Are Light, Strong, Re-Usable

Durable Exterior Plywood Builds Sea-Going Fishing, Work Craft

DIMENSIONALLY STABLE



Big Plywood Panels Speed Work On Building and Remodeling Jobs

NATURAL BEAUTY

Smart Move!

● Checkmate *your* production problem! Here's a versatile, economical, fast-to-work, hard-to-hurt material that can help you *right now!* Whether you need a material to speed work on a plant or a product, a tough, all 'round packaging and maintenance material or a dependable alternate for critical metals . . . make the *smart* move—to plywood. For information or technical assistance on special problems, write: (USA Only) Douglas Fir Plywood Association, Dept. 459, Tacoma 2, Wn.

Douglas Fir

Plywood

AMERICA'S BUSIEST BUILDING AND INDUSTRIAL MATERIAL

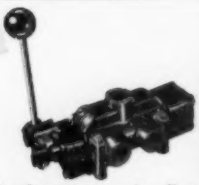
ADEL *Industrial Hydraulic Equipment*

for PEAK PERFORMANCE ADEL Hydraulic Valves and Pumps are setting new and ever higher standards for precision in manufacturing and efficient performance in operation. Following are but a few of the wide variety of models to meet all operating conditions.

GEAR-TYPE HYDRAULIC PUMPS

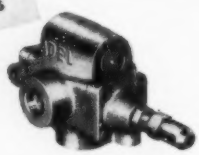
For 1000 psi service with rated capacities at 1800 rpm of from 1.5 to 46.8 gpm.

DIRECTIONAL CONTROL VALVES



4-way valves with spring-centered, spring-offset, and 1, 2, or 3 position detent action. 1500 psi. Flows to 28 gpm.

BY-PASS VALVES



Relief, Sequence and Unloading valves. Direct or remote operation, 50 to 1500 psi range.

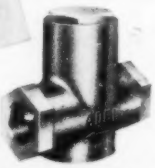
VOLUME (FLOW) CONTROL VALVES

Compensated type maintains constant flow over wide differential pressure range. No drain line required. 1500 psi.

PILOT VALVES

2 or 3 position detent. With or without dog or lever. Can be used as 4-way valve in small circuits. 1000 psi.

CHECK VALVES



Valves allow free flow in one direction only. Many variations available. 3000 psi.

A FEW SELECT TERRITORIES ARE STILL AVAILABLE TO PROGRESSIVE DISTRIBUTORS OF HYDRAULIC EQUIPMENT. INQUIRIES INVITED.

For complete engineering specifications and counsel, Address: ADEL DIVISION—GENERAL METALS CORPORATION, 10767 Van Owen Street, Burbank, California.

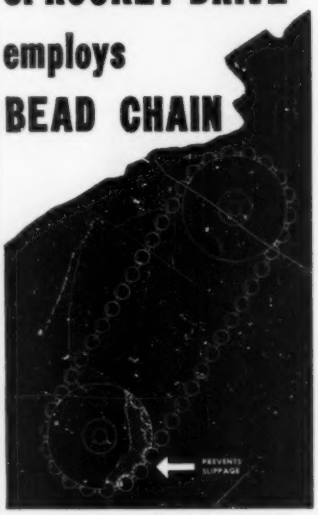
ADEL LEADER IN HYDRAULICS

DIVISION OF GENERAL PORATION • Burbank, Calif.

Manufacturers of Industrial Hydraulic Valves and Pumps

DISTRIBUTORS: AIR & HYDRAULIC ENGINEERING CO., NEW HAVEN, CONN. • RUSS CHAMBERLIN COMPANY, PORTLAND, OREGON • J. BOYD COATES, PHILADELPHIA, PA. • FRANK T. DONNELLY COMPANY, PITTSBURGH, PA. HASKEL ENGINEERING & SUPPLY CO., SAN FRANCISCO, CALIF. • HASKEL ENGINEERING & SUPPLY CO., GLENDALE, CALIF. • HYDRAULIC BRAKE SUPPLY CO., PHOENIX, ARIZ. • LINCOLN SUPPLY CO., PROVIDENCE, R. I. • SCOTT EQUIPMENT AND ENGINEERING COMPANY, DAYTON, OHIO • H. F. SODERLUND CO., SEATTLE, WASH. • ROBERT TAYLOR & SONS, SALT LAKE CITY, UTAH • WYATT SALES COMPANY, CLEVELAND, OHIO • CORBY SUPPLY COMPANY, ST. LOUIS, MO. • INDUSTRIAL AIR & HYDRAULIC EQUIPMENT CO., DETROIT, MICH.

EFFICIENT, LOW-COST SPROCKET-DRIVE employs BEAD CHAIN



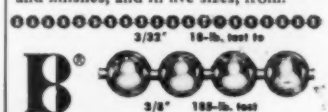
Because of its unique characteristics, Bead Chain is frequently employed by alert designers to make a simple, low-cost and highly efficient sprocket drive. Ideal for many products, it has been proved on business machines, television tuners, venetian blinds, etc. Slippage is absolutely prevented as each bead fits into an individual pocket.

Just check the qualities you want in a drive chain against the qualities offered by Bead Chain: It will not kink, bind, jam or shrink. It is completely flexible, strong, light, rustproof and long-wearing. Because every bead acts as a universal joint, changes in direction of pull are easily made.

SOLVES MANY DESIGN PROBLEMS

BEAD CHAIN—the chain you think of first as an electric light pull is truly "the Kinkless Chain of a Thousand Uses"—serving many industries and solving a wide variety of design problems. It may pay you well to check your product for opportunities to reduce costs and add sales appeal with this unique chain.

Bead Chain is available in many metals and finishes, and in five sizes, from:



The BEAD CHAIN® Mfg. Co.

92 Mountain Grove St., Bridgeport 5, Conn.

Manufacturers of: BEAD CHAIN—the kinkless chain of a thousand uses, for fishing tackle, novelty, plumbing, electrical, jewelry and industrial products; **MULTI-SWAGE**—the most economical method of producing small tubular metal parts for electronic and mechanical applications.

"EMERGENCIES" DON'T LAST FOREVER

WILL YOUR PRODUCTS FOR THE FUTURE BE READY AT THE RIGHT TIME?

TYPICAL EXAMPLES OF STAMPINGS WE MAKE FOR HUNDREDS OF COMPANIES

Commercial Fruit Juicer
Tub and Cover for Portable Dishwasher
Base for Power Lawn Mower
Street Light Shade
Safety Guard for Power Tools
Auto Oil Pan

WRITE FOR FREE BOOK

"Science and Skill in Sheet Metals." It illustrates many jobs produced for G. P. & F. customers . . . gives complete data on our facilities.

Now is the time to make plans for tomorrow's products. While new or redesigned products must be temporarily shelved because of shortages, the time is ripe for plans and development work.

And may we make this suggestion. Don't let your product planning stop at the drawing board stage. Instead of filing these ideas, send them to G. P. & F. Perhaps we can offer suggestions for production economies. Then let us give you an estimate for tools and unit costs *and, if they are okay, let us build the tools.*

Then you are really ready when the "green light" comes. *Months of precious time will be saved when it really counts.* You'll be in production — jumping the gun over others who are scrambling for ideas and sales.

STAMPING • DRAWING
FORMING • TINNING
GALVANIZING • WELDING
VITREOUS ENAMELING
SPRAY FINISHING
LEAD COATING

Metal Fabricating and Finishing has been our business since 1880

7 Acres of Production Facilities . . . Complete Tool and Die Department

G.P.&F. CONTRACT DIVISION

GEUDER, PAESCHKE & FREY CO.

1500 N. Point Ave.

MILWAUKEE 1, WISCONSIN

While you are planning for tomorrow, let us produce for you today. Sub-contract the metal stampings needed on your Defense Orders. Send blueprints to G. P. & F. for prompt quotations.

WARNER OPENS A NEW CHAPTER IN MACHINE DESIGN

electric motion control

...with 6 outstanding design advantages

Electric **BRAKES**

Electric **CLUTCHES**

Electric **CLUTCH-BRAKES**

Electric **POWER CONVERSION UNITS**

Now you can take a completely new approach to your starting and stopping problems! Let your imagination soar as you consider these outstanding design advantages in relation to *your* product. It is quite possible that the infinite degree of control—feasible only with *electric* brakes and clutches—can lead to remarkable advances in the performance of *your* machines.

1. *Lightning fast starts or stops*—or as gradually as you require
2. *Minimum shock on gear trains and shafts*—torque builds up rapidly, but gradually from zero as required to eliminate back lash
3. *High heat dissipation rate*—patented Warner feature assures longer life. As speeds increase, heat dissipation rate increases
4. *Easily adjusted torque*—automatic or manual adjustment of torque to load
5. *Easily designed into machine*—compact units (no cumbersome linkage or piping systems)—simple electrical controls
6. *Low cost*—usually lower first cost—no maintenance costs—low replacement costs. Pay for themselves quickly with savings in production time.

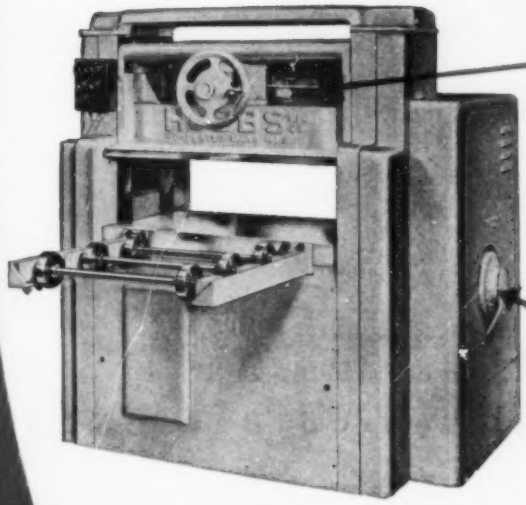
WARNER

ELECTRIC BRAKES AND CLUTCHES

WARNER ELECTRIC BRAKE & CLUTCH COMPANY, BELOIT, WISCONSIN

Typical example of *electric* motion control

HOBBS TRI-POWER DIE PRESS



Small, sensitive switch in head measures deflection as press trims paper, plastics, textile, rubber goods. When press is overloaded (.020 deflection) operation is stopped instantaneously, preventing breakage.

WarnerElectricClutch-Brake Unit gives quick, smooth, "shockless" starts and stops. Constantly self-adjusting. Minimizes maintenance. Assures longer wear, trouble-free operation. Simple, compact—easily designed into press.

One-station control on left frame at arm level gives complete cycle, jog, or continuous run action.

Power, smoothness, stops and starts . . . Longer wear . . . Less maintenance . . . Trouble-free operation

A Warner Electric Brake-Clutch Unit replacing a mechanical brake and clutch brought noticeable improvement to the operation of this Hobbs Tri-Power Die Press. Gone are the multiplicity of parts . . . the need for constant adjustment and maintenance . . . the slower starts and stops. Now the press has a new responsiveness, a new flexibility. Perhaps your product can be similarly improved. Let Warner help you with your problems of clutching, braking, automatic control, shock, and torque. Phone our nearby representative or send coupon.

FREE! HELPFUL DATA BULLETIN No. 703

It's yours for the asking. "A New Approach to your Clutching and Braking Problem." Complete with data tables, graphs, formulas, applications. Paste coupon on penny postcard and mail for your FREE copy.

Warner Electric Brake & Clutch Company, Dept. P-2, Beloit, Wis.

☐ Please send your FREE Bulletin No. 703

☐ Have your representative call to discuss my problem

Firm Name.....

Individual.....*Title*.....

Address.....

City.....*State*.....

AHLBERG
• Rugged Deep Groove Races of Chrome Alloy Electric Furnace Steel
• Large Micro-Lapped Chrome Steel Balls—Matched in Sets Within .000025"
• Lip-Type Balanced Retainers —Maximum Rigidity and Strength —Longer Life
AHLBERG
PRECISIONeered BEARINGS
Engineered and Built for the World's Finest Equipment
Automotive • Industrial • Aircraft • Marine • Armament

Put the x-ray on today's most modern military and civilian equipment and you'll see Ahlberg Ball Bearings doing an exceptionally wide variety of the load carrying tasks vital to efficient and economical operation. Because Ahlberg's are "job-engineered" for the duties they perform you'll find them assigned to the tough spots in aircraft, transportation vehicles, armament, marine, mining and all kinds of industrial equipment.

It all adds up to an unprecedented demand on which we're working night and day to supply . . . for we know that doing so means speeding the security of our nation—strengthening the future well-being of American business.

We invite your inquiries on the basis that immediate delivery promises are next to impossible, but that we will continue to produce for—and supply—civilian requirements to the extent possible within the framework of the national policy.

AHLBERG BEARING COMPANY, 3025 West 47th Street, Chicago 32, Illinois

It pays to use your custom molder's know-how

for the dielectric strength and stability required in aircraft disconnect panels

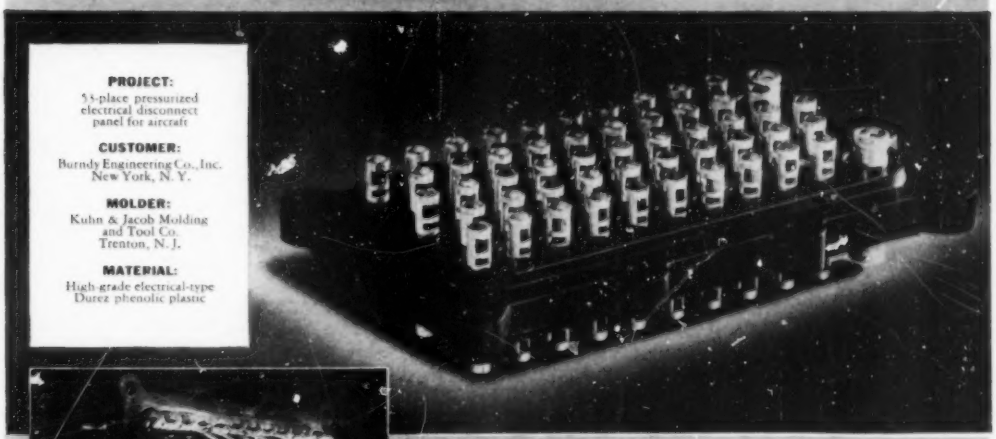
No. 29 in a Series on Plastics Skill at Work...

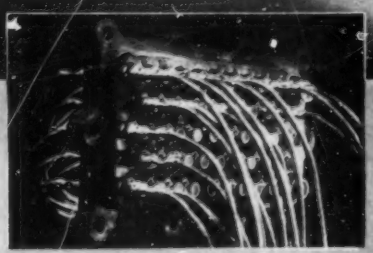
PROJECT:
53-place pressurized electrical disconnect panel for aircraft

CUSTOMER:
Burndy Engineering Co., Inc.
New York, N. Y.

MOLDER:
Kuhn & Jacob Molding and Tool Co.
Trenton, N. J.

MATERIAL:
High-grade electrical-type Durez phenolic plastic





THIS BURNDY DISCONNECT PANEL, of plunger molded electrical-grade Durez phenolic, holds 53 metal alloy socket inserts in position where controls lead from interior to exterior of aircraft. Modern molding procedures and self-insulating materials enable producers to meet increasingly high specifications in components . . . close tolerances, durability, and safety.

● The two faces of this 53-place disconnect panel live two different lives. Being inside the pressurized area of the aircraft, one face serves under the favorable conditions maintained for the comfort of passengers. But the other panel face is *outside* of this area and hence exposed to the sharply varying pressures and temperatures of substratosphere flight.

What explains its trouble-free performance under such conditions? The material itself . . . a standard Durez phenolic developed to meet unusual electrical requirements . . . and the experience and skill of the parts producer and the custom molder.

With the right Durez plastic decided upon, Kuhn & Jacob engineers were able to work out a mold design that results in "clean" molded-in socket inserts. No finishing is necessary. Proper design and production technique assure perfect contact in the precision-machined inserts, at the same time preserving the dielectric, mechanical, and surface properties inherent in this heavy-duty plastic.

Your custom molder's aim is to give you the best buy in plastics engineering, performance, and delivery speed. His unbiased recommendations on using Durez stem from long and successful experience. When wanted, the specialized experience of our field technicians is freely available.

Our monthly "Durez Plastics News" will keep you informed on industry's uses of Durez. Ask us to send a copy regularly. Durez Plastics & Chemicals, Inc., 2009 Walck Road, North Tonawanda, N. Y.

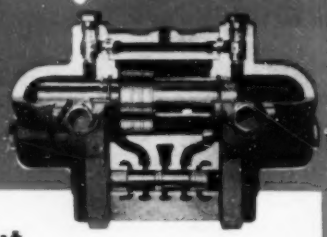
DUREZ

PHENOLIC RESINS

MOLDING COMPOUNDS
INDUSTRIAL RESINS
PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

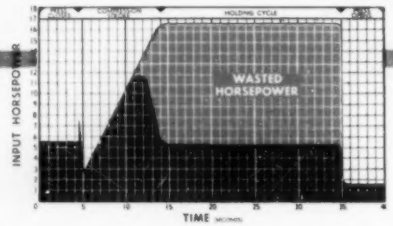
Multiply Pressure



without increasing horsepower

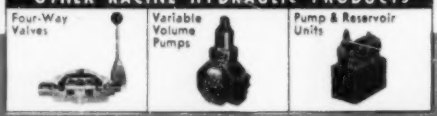
On most presses and in many other applications, pressure requirements change during the operating cycle. The Racine "Variable Volume" low pressure pump with a Racine Pressure Booster can be used to develop and hold up to 5000 psi. The horsepower input does not exceed the power needed to operate the pump at its low pressure setting.

This means lower first cost, less horsepower consumption, reduced cylinder sizes—a more compact over-all design. Pressure and volume delivered can be controlled by one of the built-in governors that are standard for all RACINE pumps.



OPERATING ECONOMIES—*The colored area in the graph above shows the horsepower lost during one holding cycle of a simple press circuit using a constant volume pump. The black area shows the horsepower consumed when a Racine "Variable Volume" Pump and Pressure Booster is used to do the same work.*

OTHER RACINE HYDRAULIC PRODUCTS



RACINE

TOOL AND MACHINE COMPANY

1772 State Street, RACINE, WISCONSIN, U. S. A.

Write for New 2-color Catalog P-50

Imperial

TRACING CLOTH THAT DEFIES TIME

• The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

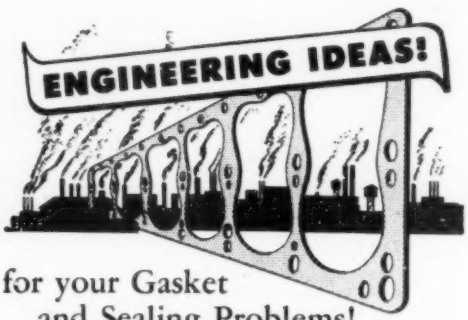
Imperial takes erasures readily, without damage. It gives sharp contrasting prints of even the finest lines. Drawings made on Imperial over fifty years ago are still as good as ever, neither brittle nor opaque.

If you like a duller surface, for clear, hard pencil lines, try Imperial Pencil Tracing Cloth. It is good for ink as well.

Imperial

TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE



for your Gasket and Sealing Problems!

Looking for new ideas on gasketing or sealing? Let Fel-Pro Engineers help you solve these problems. For over 30 years Fel-Pro has designed and developed sealing materials, gaskets, etc. for industry. This experience can be put to work for you. Send us details and specifications on any of your specific requirements for our cost-cutting, product-improving ideas and recommendations. Write: FELT PRODUCTS MFG. CO., 1534 Carroll Avenue, Chicago 7, Ill.

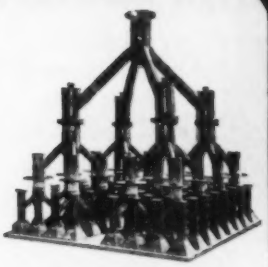
5626NED

FEL-PRO Utilize Newest Materials

ENGINEERED

Specifically designed for your product **gaskets**

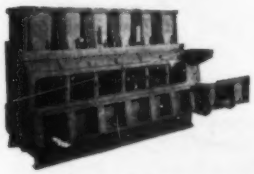
Steel-Weld FABRICATION



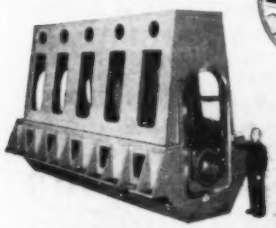
One of Several Parts of a Catalytic Cracking Plant Produced for the Petroleum Industry.

Pressure Vessels for the Chemical and Allied Industries.

Heavy Press and Machine Frames and Bases for the Machine Tool Industry.



Diesel Engine Crank Cases and Frames for the Marine and Electro-Motive Field.



Crank Cases, Frames, and other Parts for Manufacturers of Marine Steam Engines of Uniflow or Multiple Expansion Type.

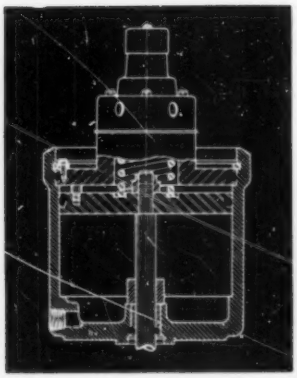
Use WELDED STEEL for Greater Strength with Less Weight!

The Steel-Weld Fabricated Roll-Over Fixture illustrated above, with end frames eleven feet in diameter, is another excellent example of a unit which could not be economically produced by any other method . . . it is typical of thousands of heavy machinery parts and assemblies produced by Mahon for many manufacturers. If savings in either time or cost can be effected in your operations through Steel-Weld Fabrication of parts or fixtures, or if you are cramped for manufacturing space, it will pay you to investigate Mahon facilities. You will find an unique source with complete, modern fabricating and machining facilities for any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures you a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON



longer service
less
maintenance
...with

LINEAR "O" RINGS

Today, when longer service-life and less maintenance of operating equipment are of prime importance, it is natural that all sealing requirements of the unique Conoflow Cylinder Operators are met with Linear "O" Rings. The one-piece piston is precision fitted with a self-lubricating Linear "O" Ring. The head plate and piston stem also are "O" Ring sealed, thus eliminating the need for head bolts and gland packing.

Linear "O" Rings are compounded of natural or synthetic rubber, fluorethylene polymers, and "Silastics" . . . are molded in a complete range of J.I.C. and A.N. standard sizes, as well as hundreds of non-standard sizes and special shapes. Precision molded under rigid laboratory control, Linear "O" Rings may be depended upon for continuous and lasting service.

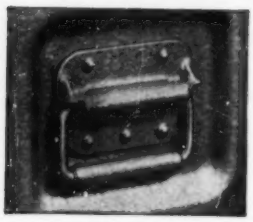
For easier installation and reduced maintenance, it will pay you to consult Linear during the design stages of your sealing applications.

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILADELPHIA 35, PA.

We've Built a BETTER HANDLE!



FOR MANUFACTURERS OF PORTABLE EQUIPMENT, CARRYING CASES, PARTS BOXES, Etc.!

- non-rattling
- rugged construction
- rust-proof
- meets Air Force and other Government specifications

Here is the handle you have been looking for—one that is ideally suited for anything that must be lifted by a side carrying handle. Because we could not buy anywhere a satisfactory handle for the thousands of cases manufactured by Bendix and needing such an item, Bendix-Friez engineers developed this handle to meet Air Force and other Government specifications for many kinds of special equipment. The unique, rugged design of this handle, with its "snap-back" feature, is such that neither shock nor vibration will cause it to rattle. Built of aluminum and stainless steel, it can be riveted or welded to the side surfaces of any kind of container or depressed in the sides. Available in large or small lots, orders filled promptly. Write for prices.

Bendix-Friez

FRIEZ INSTRUMENT DIVISION of Bendix Aviation Corporation
1336 Taylor Avenue
Baltimore 4, Maryland
Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N.Y.

Plastic

EXTRUSIONS

FLEXIBLE and RIGID

any special shapes:

RODS
TUBES
STRIPS
BELTING
EDGING
BINDING

- POLYSTYRENE
- CELLULOSE ACETATE
- POLYETHYLENE
- VINYLS
- ETHYL CELLULOSE
- BUTYRATE
- ACRYLIC

GERING PRODUCTS INC.
KENILWORTH, N.J.

Write Dept. PE

Important!

to everyone designing and making equipment for the armed forces

THIS NEW...

ALEMITE LUBRICATION FITTING CATALOG

YOURS FREE . . . **To Help You Speed Detailing and Specifying . . . Showing the New Alemite Surface-Check Hydraulic Fittings and Other Alemite Military Fittings Described in Accordance with the 1951 MIL-STD Specifications MIL-F-3541**

Get yours now! This complete, up-to-the-minute showing of genuine, quality-proved Alemite Lubrication Fittings . . . all conforming to the new 1951 Military Establishment Specifications which supersede and consolidate all previous government fitting specifications. Here, at a glance, you can choose from approved military fittings . . . highest quality fittings from Alemite, the leader and pioneer in the field of lubrication.

Whether you are designer, engineer, draftsman, plant man—if you are concerned with production of equipment for Ordnance, Navy or Air Force—you will find it easy to transfer all information to your own blue prints. All fittings are illustrated actual size . . . all with photographs and line drawings giving dimensional data . . . all with convenient cross-references to previous government standards.

MAKE SURE YOUR EQUIPMENT PASSES THE NEW GOVERNMENT INSPECTION STANDARDS! Send for your free copy now. Don't bother writing a letter. Fill out coupon below . . . attach to a postcard . . . and mail today!

REMEMBER: At your disposal always—no farther away than your phone—is a trained Alemite Lubrication Engineer. Consult him with confidence next time you face a fitting problem.

ALEMITE

A PRODUCT OF SW STEWART-WARNER

Alemite, Dept. T-91
1850 Diversey Parkway, Chicago 14, Illinois

Please rush me a FREE copy of your Alemite Lubrication Fitting Catalog covering the new MIL-STD Specifications MIL-F-3541.

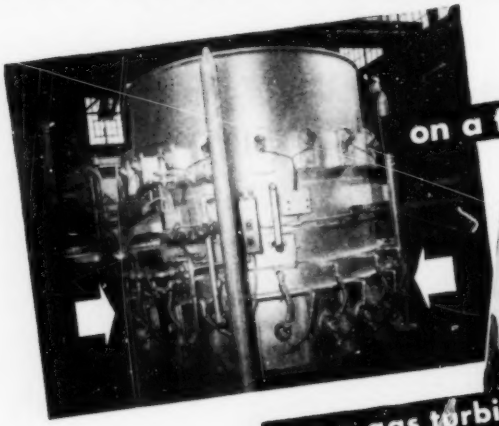
Name .....
(Please print plainly)

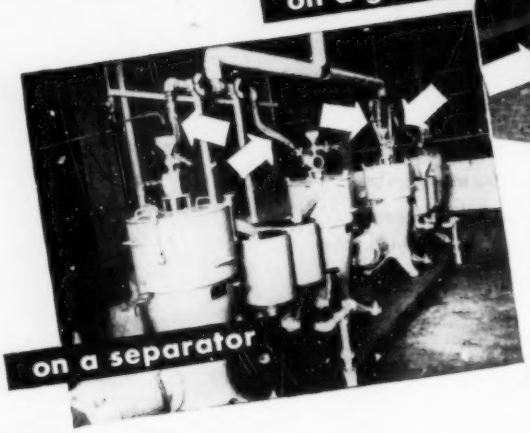
Address .....

City ..... *Zone* ..... *State* .....

Let CMH FLEXIBLE METAL HOSE

take the motion . . .





and your product *will last longer!*

In all types of connections subject to vibration, misalignment, flexation or expansion and contraction, CMH Flexible Metal Hose will solve the problem economically and dependably . . . and in most cases, it will simplify and speed up assembly of your product. The product will last longer and give better service, too, if CMH Flexible Metal Hose is used to absorb the damaging effects of motion in rigid assemblies or to relieve the stresses of misalignment.

There is a CMH hose type or standard assembly to meet virtually every need of the product designer. Write for descriptive literature, outlining the types of connection problems you have.

REX-WELD corrugated steel and bronze hose is available in standard sizes from 3/16" through 12" I.D. for burst pressures to 12,000 psi, temperatures to 1000° F. Stainless steel types also available.

REX-TUBE convoluted hose is available in a variety of types including square locked, ball bearing and fully interlocked in a variety of metals including steel, bronze and other alloys.

Flexon identifies CMH products that have served industry for over 49 years.

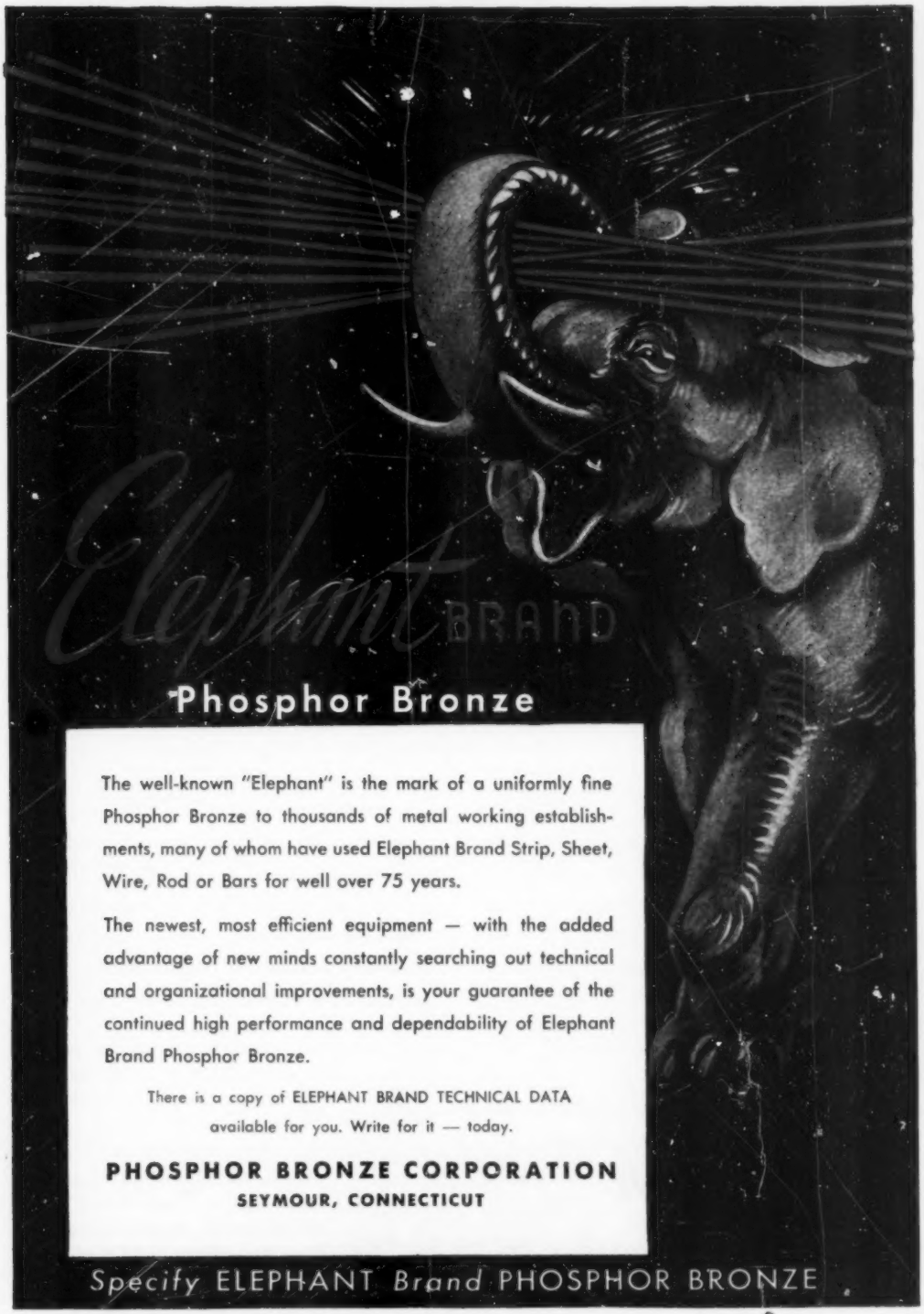
CHICAGO METAL HOSE Corporation

1351 S. Third Ave. • Maywood, Ill. • Plants at Maywood, Elgin, Rock Falls, and Savanna, Ill.
In Canada: Canadian Metal Hose Co., Ltd., Brampton, Ont.

CMH

ONE DEPENDABLE SOURCE
for every flexible metal hose requirement

Convoluted and Corrugated Flexible Metal Hose in a Variety of Metals • Expansion Joints for Piping Systems
Stainless Steel and Brass Bellows • Flexible Metal Conduit and Armor • Assemblies of These Components


Elephant BRAND
Phosphor Bronze
The well-known "Elephant" is the mark of a uniformly fine Phosphor Bronze to thousands of metal working establishments, many of whom have used Elephant Brand Strip, Sheet, Wire, Rod or Bars for well over 75 years.
The newest, most efficient equipment — with the added advantage of new minds constantly searching out technical and organizational improvements, is your guarantee of the continued high performance and dependability of Elephant Brand Phosphor Bronze.
There is a copy of ELEPHANT BRAND TECHNICAL DATA available for you. Write for it — today.
PHOSPHOR BRONZE CORPORATION
SEYMOUR, CONNECTICUT
Specify ELEPHANT Brand PHOSPHOR BRONZE

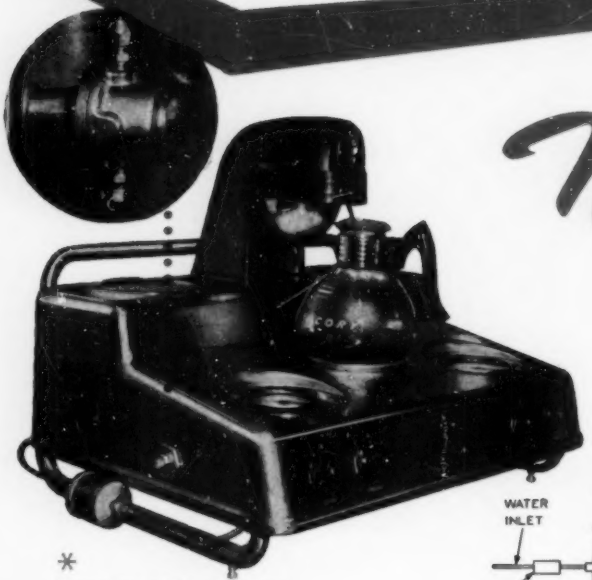
CORY Automatic Coffee Brewer

Practically ELIMINATES Regulator SERVICING...

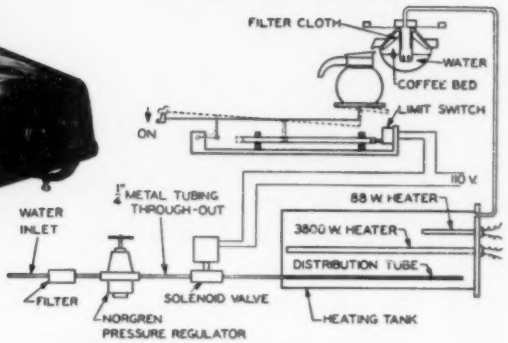
with

Norgren

REGULATORS



Bottom view of CORY coffee maker showing Norgren Pressure Regulator



● ***Identical quality*** in decanter after decanter distinguishes the CORY ***push-button automatic*** coffee brewing system—the result of close control of infusion time, coffee measure, and ***accurate flow control*** of city water.

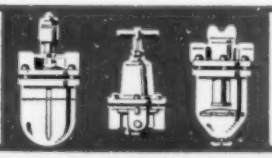
● ***Norgren Regulators*** maintain constant secondary pressure to provide a flow of 1/6 g.p.m. Cory selected Norgren Regulators after exhaustive testing of many makes because they maintain the highest degree of accuracy over the longest period of time.

25th Year of Progress

For full details write for APPLICATION DATA SHEET No. 108, C. A. Norgren Co., 228 Santa Fe Drive, Denver 9, Colo.

If your problems include closely controlled air or liquid pressure—simpler, better lubrication—excessive moisture in air lines—call for the Norgren Representative.

Norgren



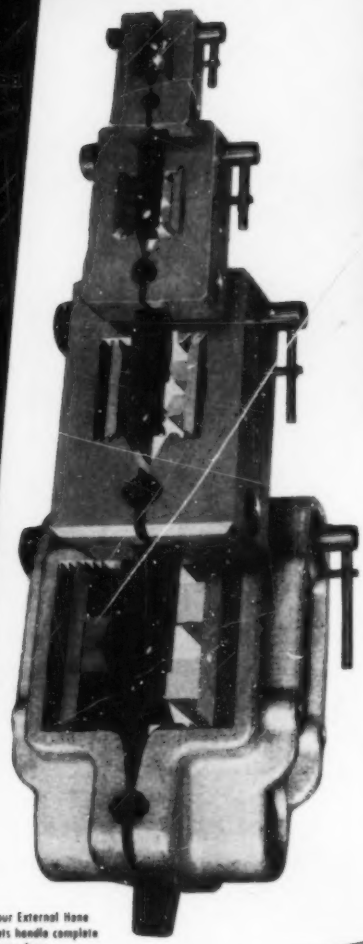
Lubricators, Regulators, Filters, Relief Valves, Check Valves, Air Governors, Needle Valves, Hose Assemblies and Couplings.

25 YEARS OF HELPING AIR POWER SERVE INDUSTRY BETTER

SUNNEN EXTERNAL HONES

Save Costly Hours in TOOL ROOM, PRODUCTION, SALVAGE

. . . Combine the Speed of Honing with the Precision of Lapping



Four External Hone Sets handle complete range from .120" to 2.750"

Ideal for sizing and finishing PINS, SHAFTS, SPINDLES, PLUNGERS, PISTONS, ARBORS, and other parts with diameters between .120" and 2.750"

Sunnen external hones use rigidly mounted abrasive stones... provide controlled stock removal, to the "last tenth"... produce any desired surface finish... are easy to use.

These precision tools enable you to:

- Obtain true geometric accuracy — dimensional tolerances to. 0001" and better.
- Produce surface finish to 2 Micro-inches in steel.
- Correct heat treat warpage, out-of-round, taper, barrel, and waviness.
- Remove centerless grind patterns and other defects — ideal for hardened parts.
- Produce parts with perfect working surfaces and the smooth, criss-cross surface finish that's best for holding lubricants.

TYPICAL APPLICATIONS

FREE ILLUSTRATED FOLDER

gives full description, with details of typical applications. Mail the coupon for your copy.

630

SUNNEN PRODUCTS COMPANY
7900 Manchester Avenue • St. Louis 17, Missouri
Canadian Factory: Chatham, Ontario

To: SUNNEN PRODUCTS CO.
7975 Manchester Ave., St. Louis 17, Mo.

☐ Please send bulletin on external honing. ☐ Have representative call.

Name.....

Company.....

Address.....

City.....Zone.....State.....

AVOID VERBAL ORDERS
Must check cord assembly department—
Too many rejects—
Costs us money—
Too much inspection required—
Too much lost production time—
Too many service calls—
Engineering should look into those Belden Cords
Belden
Complete Cord Sets
Finished to your exact requirements. Save production time. Cut out rejects and failure in service.

A scrap of paper that led to a Class A product improvement. Let us prove that these savings are possible in your plant, too.
WRITE: Belden Manufacturing Co. 4691 West Van Buren Street Chicago 44, Illinois

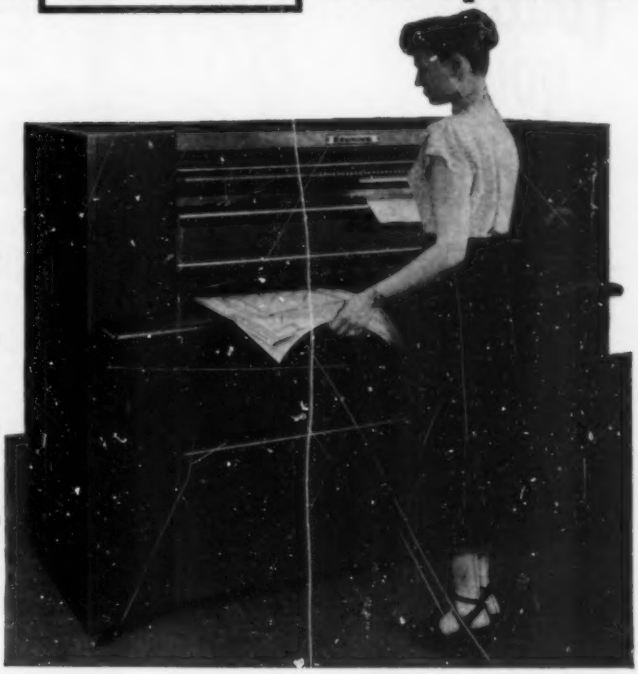
Corditis-Free Cords by

Belden

WIREMAKER FOR INDUSTRY

NEW — a low-cost* whiteprinter

ANNOUNCING BRUNING'S MODEL 20 COPYFLEX



Here's the new Bruning Model 20 Copyflex. Because of its low price, thousands of companies now can make their own whiteprints and thus realize a substantial saving. Now you can produce your whiteprints *when* you want them — as you want them.

It will pay for itself by producing sharp, clean prints of your engineering drawings as well as copying your production orders, reports, specifications, defense order copies, etc.

The Model 20 is a completely new, medium volume machine of advanced design, yet sells for the lowest price of any machine in its class. It has a full 46" printing width, and takes cut or roll stock.

Compare these advantages

- ***LOWEST PRICED** machine of its class available.
- **NO FUMES.** Bruning Copyflex machines use no vapor developer, therefore cannot possibly emit unpleasant fumes.
- **NO INSTALLATION.** No exhausts needed. Just connect to an ordinary 115 volt AC electric power circuit.
- **EASY OPERATION.** No training needed — anyone can operate a Copyflex.

See how the Model 20 Copyflex, or one of our other models, can help you. There is a model for every price and volume requirement. Clip the coupon now and you'll be on the road to faster, less expensive copying.

BRUNING

Specialists in copying since 1897

CHARLES BRUNING COMPANY, INC.

Dept. V-91 100 Reade St. New York 13, N. Y.

☐ Send me full details on the Model 20 Copyflex.

☐ I would like to see a Copyflex machine demonstrated.

Name_____ Title_____

Company_____

Street_____

City_____ Zone_____ State_____

Could you produce this part for 19¢*

This pawl is a vital part of a Bazooka

* in tool steel to maximum tolerances of ±.003"

Casting Engineers, Inc.,
can produce this part for 19c because our method of investment casting permits the use of mass production principles by casting, in this instance, 108 pieces at one time.

Investment Casting
eliminates handling of raw material stock.

Investment Casting
eliminates drill press and operator

Investment Casting
eliminates milling machine and operator

Investment Casting
eliminates service failures and spoilage.

Casting Engineers', Inc.
method is resulting in substantial economies in the production of metal parts of all kinds, especially those of intricate design or where materials used make it impossible or costly to machine.

ENGINEERED PRECISION CASTINGS

For a guide to important savings, send today for new booklet "Cost Reductions Through Investment Castings"

CASTING ENGINEERS

INCORPORATED

2323 BOSWORTH AVENUE, CHICAGO 14, ILL.

THREE SAFE, SURE CONTROLS for HAZARDOUS LOCATIONS

Enclosed in Approved Blast-Proof, Dust-Tight Housings

TYPE EJO THERMOSTAT A precisely adjustable control. Narrow calibrated ranges for liquids or gases. Adjustable ranges, 120 F or 250 F between limits of −120F and 600F. Ratings AC 1200 watts 125-250 V AC. Uses any United remote bulb assembly.

TYPE EJR VACUUM SWITCH For close differential control on exposed applications. Ranges from 0-180 psi pressure, 30" Hg vac to 20 lb. press. Diff. 4" WC to 2 lb. adjustable or fixed at customer's option.

TYPE EGL PRESSURE CONTROL A rugged pilot switch for industrial uses involving the control of air, gas and liquids. Ranges from 0-350 psi. Diff. from 2-15 psi, electrical ratings AC 1200 watts 125-25 V AC.

All controls tapped for standard pipe fitting. All may be mounted in any position.

Write for complete details today

UNITED ELECTRIC CONTROLS COMPANY
81 School Street
Watertown, Mass.

STANDARD & SPECIAL THERMOSTATS & PRESSURE SWITCHES

CONTROL POWER BETTER

CLUTCH PROBLEM?
Call in a ROCKFORD clutch engineer. Make use of his quarter century of clutch designing and building experience. Thousands of manufacturers, in almost every industry, have licked their power transmission control problems—with the right type, size and capacity clutch application
—from the complete ROCKFORD line. Let ROCKFORD engineers help solve YOUR clutch problem.
ROCKFORD CLUTCH DIVISION
BORG-WARNER
309 Catherine Street, Rockford, Illinois

ROCKFORD CLUTCHES

CONTINENTAL SCREW COMPANY
INC. ★ 1904

You can count on Continental

CONTINENTAL SCREW COMPANY
New Bedford, Mass.

Manufacturers of famous HOLTITE-Phillips and Slotted Head Screws and Bolts and Allied Fastenings, both Special and Standard

HOLTITE PRODUCTS

Leather Crimping Machine
Air-Powered by NOPAK Cylinder

FRONT VIEW shows crimping blade and adjustable heated jaws; air and thermostat controls mounted at left.
REAR VIEW shows NOPAK Model "E" 4" x 8" stroke Cylinder, with self-regulating cushion at both ends.

The crimping machine pictured was developed by Western Supplies Co. of St. Louis. It "makes shoes fit better" because it preforms leather upper sections, under heat and pressure, so that they can be subsequently drawn snugly against the lasts.

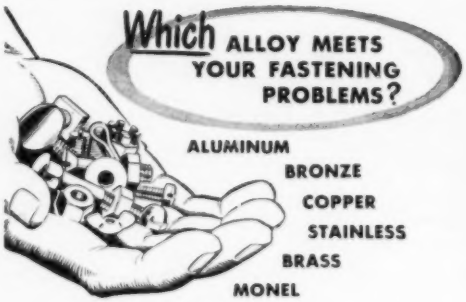
NOPAK Air Cylinder Power was chosen to reduce operator fatigue and increase production . . . to utilize controlled line pressure over the full range of crimping operations . . . to eliminate working parts . . . and because NOPAK mounting characteristics were best fitted to the machine. A study of the cylinder's construction indicated there was "practically nothing to wear out." It was also found to meet the high standards required at a comparatively low price.

GALLAND-HENNING MFG. CO.
2762 S. 31st St. • Milwaukee 46, Wis.
Representatives in Principal Cities.

A 5958-½H-A

Write for Bulletin SW-1 or refer to Sweet's File for Product Designers.

NOPAK
VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

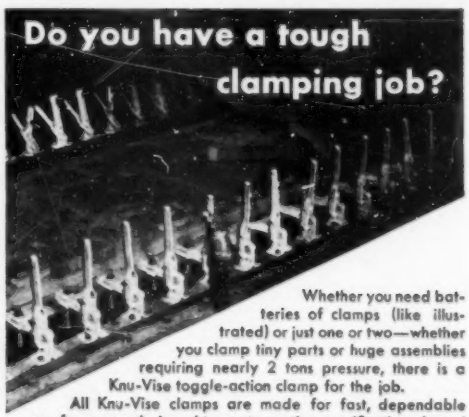


Let HARPER Help. Here are *all* kinds—with exactly the right alloy, size, type and finish you need. Harper specializes in nonferrous and stainless steel fastenings for services in all industries where resistance to corrosion, abrasion, heat and stress is vital. Over 7000 items—bolts, screws, nuts, rivets, and accessories—in stock ready for immediate delivery from warehouses and distributors, coast to coast. For latest catalog, mail coupon.

HARPER
EVERLASTING FASTENINGS

The H. M. Harper Co.,
8205 Lehigh Ave., Morton Grove, Ill.
Rush my copy of the Harper Catalog.
(Please Print)
Name .....
Address .....
City ..... State.....

SPECIALISTS IN ALL NON-CORROSIVE METALS



Whether you need batteries of clamps (like illustrated) or just one or two—whether you clamp tiny parts or huge assemblies requiring nearly 2 tons pressure, there is a Knu-Vise toggle-action clamp for the job.

All Knu-Vise clamps are made for fast, dependable performance, designed to most exacting specifications, based on exhaustive laboratory tests and years of practical use.

Call on our engineers (without obligation) if you want to know whether your clamping is as efficient as it should be.

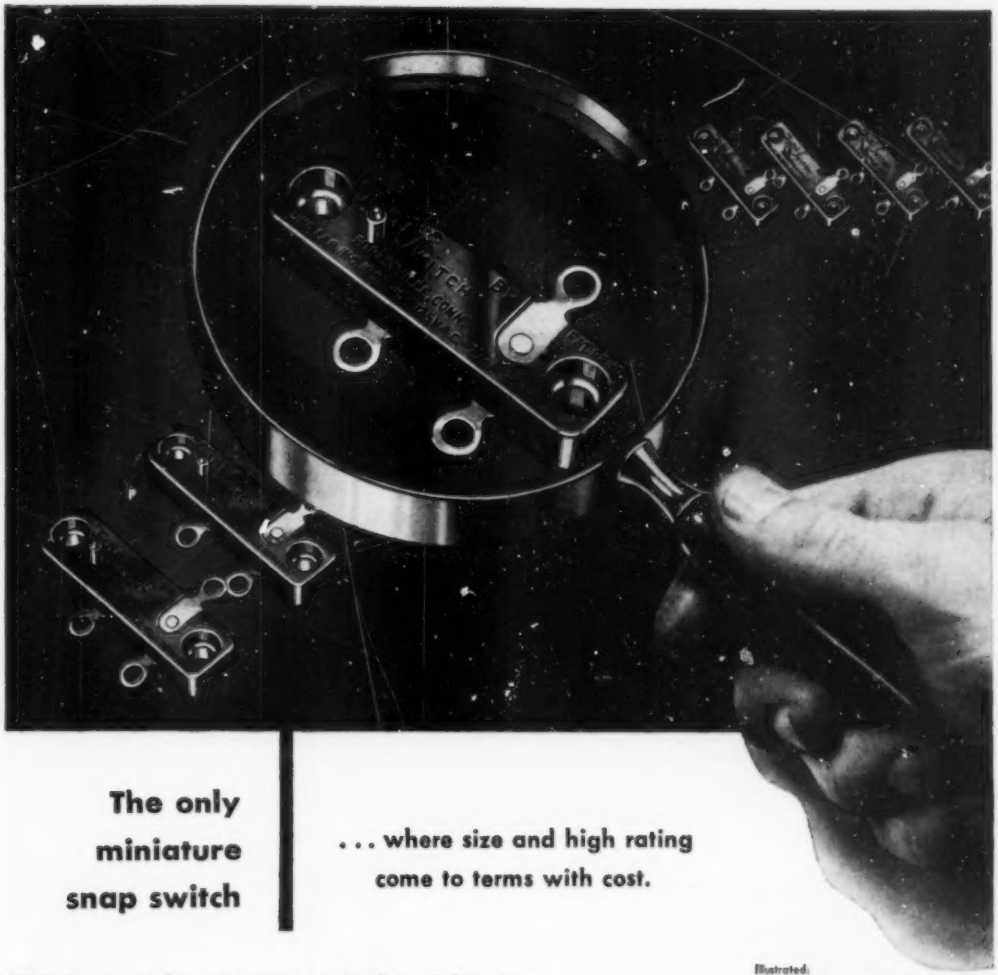
Would you like one of our new catalogs?

Photo Courtesy Consolidated Vultee Aircraft Corporation

Sales Offices in Principal Cities

KNU-VISE PRODUCTS
LAPEER MFG. CO.
3058 DAVISON ROAD • LAPEER, MICHIGAN

WESTERN DIVISION: 422 MAGNOLIA ST. GLENDALE, CALIF.



The only miniature snap switch

. . . where size and high rating come to terms with cost.

Illustrated:
Model BP, single-pole, double-throw, 15A., 125 V. A.C. Overall length, 1⅝"

With the present-day cost squeeze coming from all directions, harassed engineers find the benefits of TYNISWITCH more welcome than ever.

Now, new product designs can provide for high load switching in small spaces at even *lower cost* than was previously possible. The simplified construction principles, found only in TYNISWITCH, mean smooth, dependable performance without the need for costly, non-functional bulk. Under exhaustive laboratory tests, TYNISWITCH has demonstrated consistent reliability at high operating speeds and over millions of cycles.

TYNISWITCH is available in a variety of standard stock models — or new models can be developed economically for your particular application. Write for complete details. Tyniswitch Division, The Sessions Clock Company, 101 East Main Street. Forestville, Connecticut.

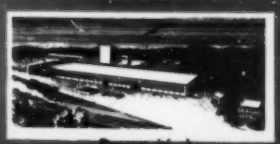
BACK IN THE 1880's

WHEN THE FIRST NEW YORK TO CHICAGO TELEPHONE COMMUNICATION WAS OPENED

Koven

WAS MAKING INDIVIDUALIZED EQUIPMENT PARTS

Over a thousand miles apart, yet for the first time men could discuss business on the first New York to Chicago telephones as easily as across the conference table. More than likely the name of KOVEN figured in many of those early calls, for even then manufacturers were using KOVEN Individualized Equipment Parts. Today, leaders in industry are still discovering the advantages of equipment parts tailored to their specific needs by KOVEN. Let us show you how we can help cut operating costs and increase the efficiency of your plant by precision-built equipment parts that are often less expensive and more quickly and easily obtained than those you can produce in your own factory. Call or write today for a consultation —no obligation.

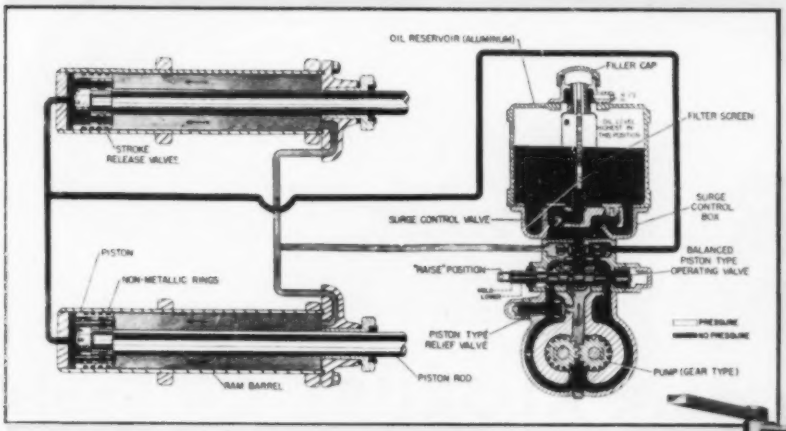


Our complete modern facilities include: Machine, welding, plate and sheet metal, galvanizing and painting shops. X-ray equipment insures quality control in every KOVEN Individualized Equipment Part.

L. O. KOVEN & BRO., INC.
154 Ogden Ave., Jersey

KOVEN FOR INDIVIDUALIZED EQUIPMENT PARTS SINCE 1881

FOR THAT "Something Extra" IN PERFORMANCE



SPEED

POWER

VERSATILITY

SIMPLICITY

TROUBLE-FREE OPERATION

DESIGN YOUR PRODUCT WITH
LaPLANT-CHOATE HYDRAULIC UNITS

FOR designers and manufacturers of products that can be improved by hydraulic operation, LaPlant-Choate Hydraulic Units give the performance "extras" which bring extra advantages into your competitive sales picture.

These powerful, smooth-operating units . . . jacks, pumps, valves or the compact, all-in-one fluid power control . . . supply the speed, flexibility, and instant response to controls that keep equipment operating economically and efficiently.

That's why so many manufacturers like the ones listed below are using LaPlant-Choate Hydraulic Systems for the utmost in full hydraulic operation. For complete details, send for Bulletin B-1152B, or write your requirements to LaPLANT-CHOATE MANUFACTURING CO., INC., Cedar Rapids, Iowa.

THE FAMOUS LPC FLUID POWER CONTROL

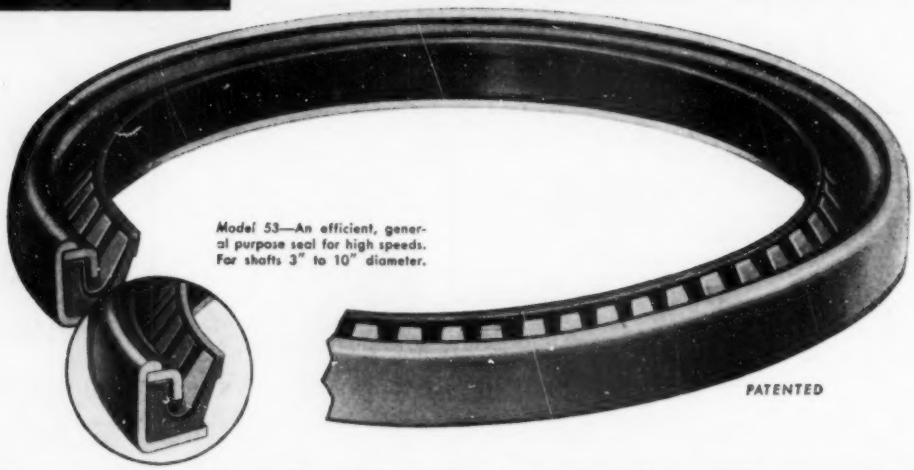
Pump, valve and oil reservoir are all combined into a single compact unit that mounts on the front of the tractor behind the radiator guard. This new "closed system" design completely eliminates long suction lines, reduces the hazard of leaks and assures greatly increased speed and efficiency. In addition, the entire unit is skillfully engineered and precision built for utmost simplicity, easy servicing, and long, trouble-free operation.

A few of the well-known manufacturers who make good products even better with LPC Hydraulic Units

Service Supply Corp. (Manufacturing Division) **THE LODOVER**	Pacific Car & Foundry Co. **CARCO HYDRADOZERS**	Municipal Supply Co. **THE GUTTER SNIPE**
The Warner & Swasey Co. **GRADALL**	Wm. Bros Boiler & Mfg. Co. **BROS BULLDOZERS**	Pittman Manufacturing Co. **THE HYDRALIFT**

LaPLANT CHOATE

Prolong the life of your bearings



Model 53—An efficient, general purpose seal for high speeds. For shafts 3" to 10" diameter.

PATENTED

Use Garlock KLOZURE* Oil Seals

SERVICE records from thousands of different installations prove that bearings *last longer* and require *less maintenance* when they're protected by Garlock KLOZURE Oil Seals. Once a Garlock KLOZURE has been installed, you have the best possible insurance that the bearing lubricant will be sealed *in*—that dirt and foreign matter will be locked *out*.

There's a service-tested KLOZURE design for practically every bearing application. These superior oil seals are produced in a wide range of sizes including Metric O. D. to fit bearing manufacturers' standard bores. A few of the most widely used models are shown here.

Write today for the new Klozure Catalog

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

GARLOCK Klozure* OIL SEAL

*REG. U. S. PAT. OFF.

Model 51—A sturdy seal for medium speeds. May be used on reciprocating rods and against moderate pressures.

Model 63—An efficient, general purpose seal for high speeds. For shafts 3" diameter and smaller.

Model 64—A strong, effective seal for heavy duty on shafts of the largest diameter.

Model 91A—A springless seal of small cross section, with the metal reinforcing member surrounded by rubber.

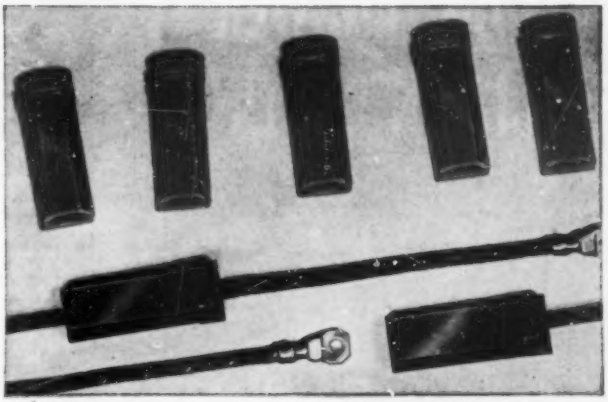
Model 91B—A springloaded seal of small cross section, with the metal reinforcing member surrounded by rubber.

Design for Automatic Molding

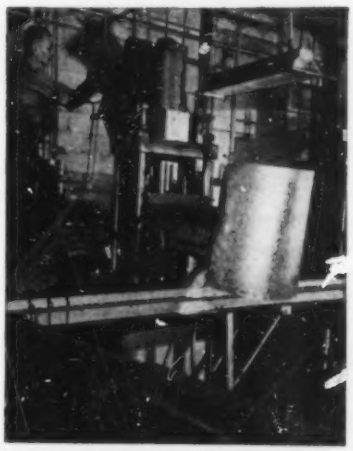
...cut labor

...cut costs

...cut investment



Plastic Insulators for electrical connections, shown in connected and disconnected positions, used in quantities for lighting and other connections on automobiles . . . made by Wade on Stokes Presses.



One of the Stokes 741 fully automatic molding presses at Wade Electric Products Company, Sturgis, Michigan. Parts drop on conveyor belt, thence to tumbler. Occasional filling of hopper is the only regular attention required.

Each unit in this installation of Stokes 741 automatic molding presses produces approximately 40,000 parts per hour which are automatically conveyed to a tumbler to remove flash.

The part is an insulator for an electrical connector, small but complex, previously considered impossible to produce automatically.

The Stokes 741 fully automatic molding press assures high production of perfect, uniform parts, and takes the place of a large plunger press with its preform press, electronic preheater, and the full-time and part-time operators required to run it.

In automatic operation one man periodically fills the hoppers with molding powder and removes the finished parts; otherwise no attention is needed.

Let Stokes experts judge from parts or blueprints if your products qualify—or can easily be re-designed for—the high production and large savings per unit which are possible by automatic molding. Or send for a 24-page brochure on Fully Automatic Molding.

STOKES

STOKES MAKES

Plastics Molding Presses,

Industrial Tabletting

and Powder Metal Presses,

Pharmaceutical Equipment,

Vacuum Processing Equipment,

High Vacuum Pumps and Gages,

Special Machinery

F. J. STOKES MACHINE COMPANY, 5500 TABOR ROAD, PHILADELPHIA 20, PA.

ONLY ONE ANSWER— PRECISION CASTING

THE terminal insert illustrated is one of Arwood's outstanding achievements. It represented a real challenge to produce the die and to successfully cast the insert in bronze.

The insert was designed for investment casting and it is an application that is almost impossible to produce by conventional production methods.

Interesting to note are the six .070 diameter holes, the three .039 diameter holes and the .050 arms connecting the bosses to the hub —all cast to maximum tolerances of .002.

Perhaps you have a production problem that Arwood can help you solve. Our engineers, with years of experience in many industries, often are able to make valuable suggestions that result in important savings in manufacturing.

For more complete information about the accuracy, the lower costs and the versatility of precision casting, write for our booklet, "A Critical Survey of Investment Castings."

ARWOOD

PRECISION CASTING CORP.

68 WASHINGTON STREET • BROOKLYN 1, N. Y.

Plants: Brooklyn, N. Y., Groton, Conn., Tilton, N. H.

PATTON-MacGUYER

PRESSED METAL

SMALL METAL STAMPINGS

In Accordance With Your Prints

Extensive modern plant, complete equipment, engineering and toolmaking skill for producing your stamped metal parts accurately, economically, promptly. Moderate die charges. Facilities for large volume production. We welcome stamping problems.

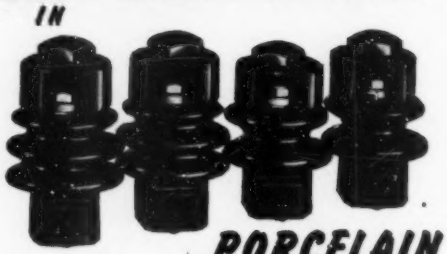
TERMINALS for ELECTRIC WIRES

Specialists in the terminal field, we have dies to produce over 400 different kinds of separate terminals. Every modern facility to meet your standard or special requirements.

PATTON-MacGUYER COMPANY

Edgewood Station Providence 5, R.I.

UNIFORM QUALITY IN



PORCELAIN INSULATORS

The quality of any insulator is the sum of its desired characteristics. Universal Porcelain Insulators have a uniform body density. They are held to close dimension tolerances. They have high dielectric and physical strength. They withstand temperature extremes, moisture, fumes, acids and corrosion. The sum of these characteristics repeated in piece after piece adds up to the Uniform Quality for which Universal Insulators are so widely known and used. A Universal insulator engineer will be glad to work with you.

THE UNIVERSAL CLAY PRODUCTS CO.

1545 EAST FIRST STREET SANDUSKY, OHIO

Look alike?

YES . . . but one is of superior quality and costs less than 1/2 as much because of *Accurate* springmaking know-how!

Given a few machines and some wire, anyone can make springs . . . the difference comes in "know-how." And that's what we have to sell at Accurate.

A good example of how Accurate know-how can pay off is the history of the two springs illustrated above. One was made in two operations and required 100% inspection with rejects running as high as 50%. Accurate know-how developed the means of producing this spring *complete in one operation with such unvarying accuracy that inspection could be eliminated.* First cost is lower . . . overall cost is lower.

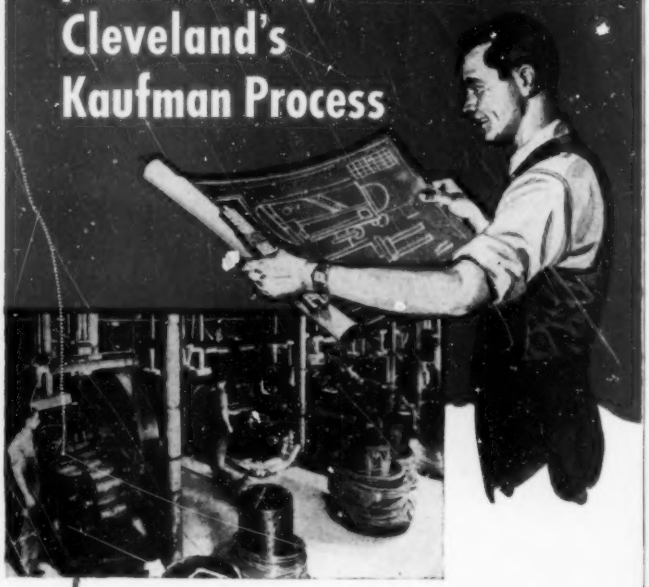
If you require precision springs in quantity, we would welcome the opportunity to go over your needs with you and make recommendations. Write today.

ACCURATE SPRING MFG. CO.
3815 West Lake Street
Chicago 24, Illinois

ASK FOR your complimentary copy of the Accurate Handbook of Technical Data on Springs. It's full of short cuts for making spring calculations.

Accurate Springs

Simplify your special parts* production problem with Cleveland's Kaufman Process



Have your unusual *fastener-type parts made to your specifications by extrusion forging. Cleveland's Kaufman Process guarantees a tougher product, accurate in every dimensional detail—usually ready for use without machining. This method is faster, therefore more economical in most cases. The steel and heat treatment you specify are followed to "the letter".

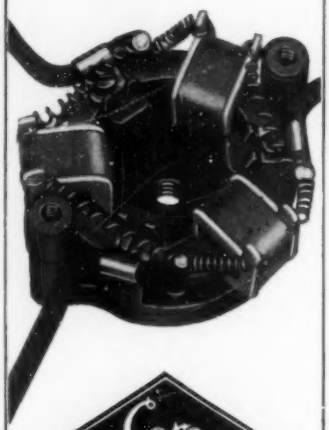
Relieve your shop of this production problem. Have your quantity-run fastener-type specials made better and faster at Cleveland. Write for folder "Specials by Specialists."

THE CLEVELAND CAP SCREW COMPANY
2917 East 79th Street, Cleveland 4, Ohio

CLEVELAND *Top Quality* FASTENERS

ONLY SPECIFIC COILS CAN DO THIS JOB-

The Bobbin Type Coils shown below are part of a complex aircraft instrument assembly. No larger than your little fingernail, these tiny coils are mounted on a common core and activate three indicator needles within the same dial. Extreme assembly care and microscopic inspection, at Coto, assure perfect operation under adverse flying conditions.



Coto SINCE 1917

Builds Them!

When you need electrical coils, why not take advantage of 34 years of experience, engineering competence, and modern production facilities. Coto coils are built for you, to your specifications.

COTO-COIL CO. INC.
COIL SPECIALISTS SINCE 1917
65 PAVILION AVE
PROVIDENCE 5, R.I.

chooses KOPPERS POLYSTYRENE 81 for a new molding technique

RECENTLY, Scripto engineers developed a new injection molding technique which simplifies manufacture of the Scripto pencil. In the past, the pencil was made of metal, and many separate operations were required to form and tip the pencil barrel. Now, the pencil barrel is injection molded. Internal threading is accomplished by use of long, narrow, retractable cores. When the molding cycle is complete, the cores are retracted. The barrels are threaded and completely formed in this one simple operation. This new technique means faster production, lower cost and a better product.

Scripto engineers found that the excellent molding qualities of Koppers Polystyrene 81 were unequalled for this delicate operation. Its dimensional stability and ease of molding make possible faster cycles and fewer rejects. And its clean, brilliant colors add to the appeal of the finished product.

Technical data on the molding characteristics of Koppers Polystyrenes are available upon request. As always, we want to work with you to obtain the best results from your use of plastic molding materials . . . to solve your particular molding problems (with special attention to military end uses) . . . and to design new products to be made from Koppers Polystyrene when the supply situation again becomes more normal.

KOPPERS

Koppers Plastics

Koppers Polystyrene has made Many Products Better and Many Better Products Possible.

KOPPERS COMPANY, INC., Chemical Division, PITTSBURGH 19, PA.

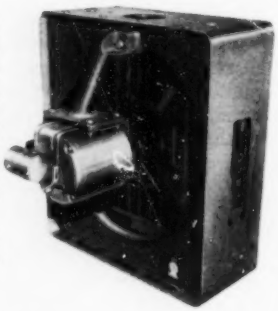
SALES OFFICES: NEW YORK • BOSTON • PHILADELPHIA • CHICAGO • DETROIT • LOS ANGELES

YOUNG
UNIT HEATERS
get Dependable Power

WHEN THE HEAT'S ON . . .

reliable Doerr Motors move it where needed. Typical Doerr heater applications are shown in the cabinet heater above and in the horizontal unit below—reliable performers from the Young Radiator Company line of top quality products.

Among the many features embodied in the Doerr Motor design for heater use is the resilient mounting specifically engineered to hold the motor securely in place during shipment and in all mounting positions. The formed clips prevent axial movement in either direction, while the hooked slots in the base prevent clips from springing outward.



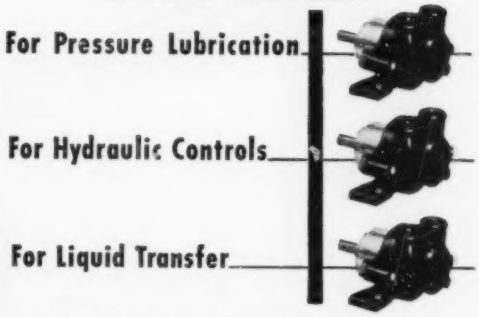
If you have an unusual motor problem please let us hear from you.

you get More with DOERR!

DOERR
Electric Corporation
CEDARBURG, WISCONSIN

Electric Motors from 1/30 to 5 hp. Standard, or Designed to Your Specifications

TUTHILL Model L PUMPS HELP SOLVE YOUR DESIGN PROBLEMS



Tuthill Model L positive displacement internal-gear rotary pumps are noted for their mechanically-sealed, leakfree performance, quiet operation, low power consumption, and long life. Capacities up to 3 g.p.m. and pressures to 400 p.s.i. Ring or foot mounting. Stripped models available for special porting arrangements.

Find out today how these dependable pumps will help solve your design problems. Write for Model L bulletin.

TUTHILL PUMP COMPANY
939 East 95th Street, Chicago 19, Ill.

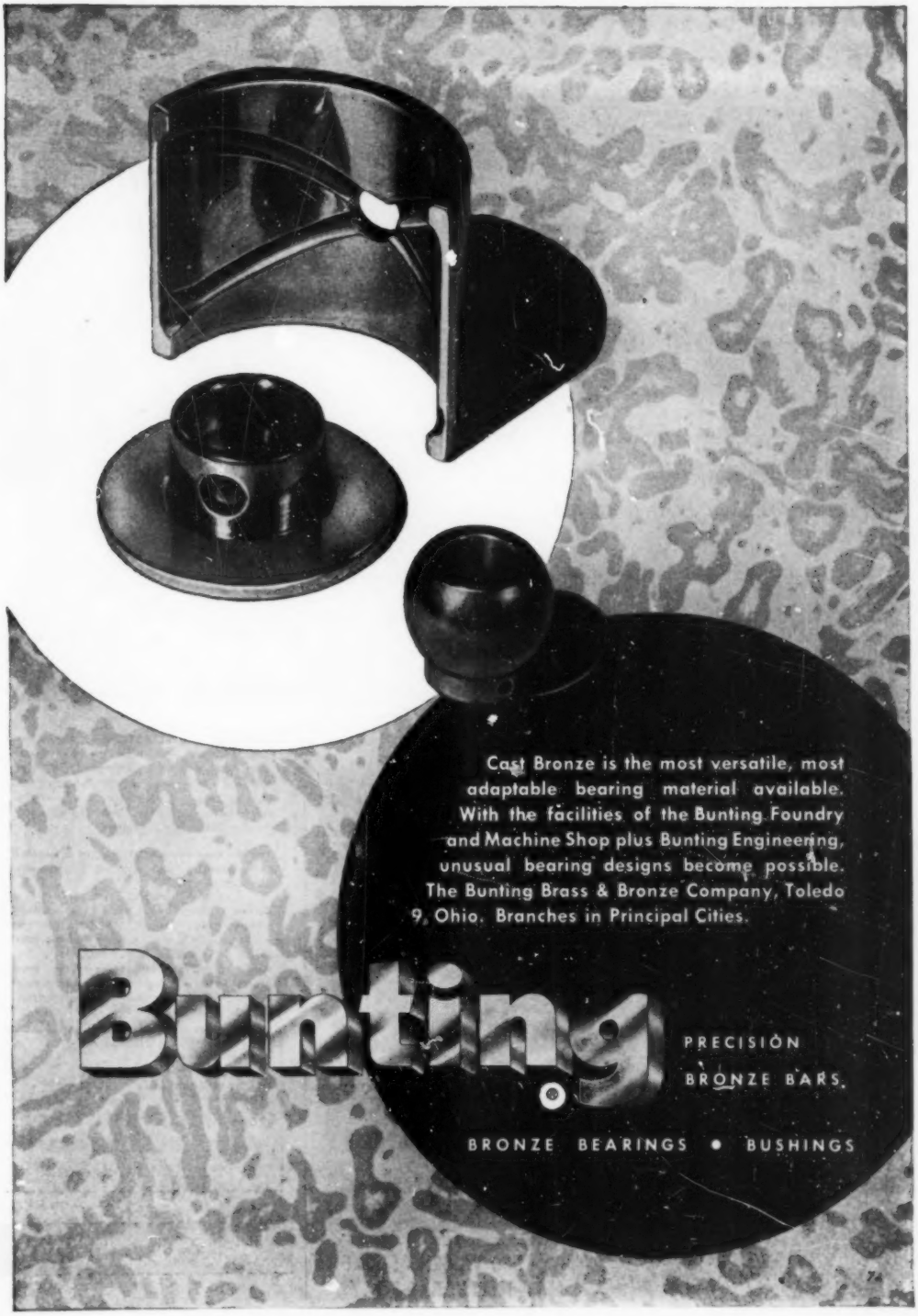
IMPORTANT DATA ON

UNIVERSAL *Flexible* METAL HOSE

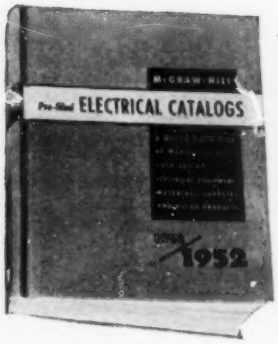
for conveyance of gases, liquids, semi-solids, dust, etc.—for moisture-proof armored conduit and control casings—and many other applications.

Write for
CATALOG U-101 — Just Published

UNIVERSAL METAL HOSE CO.
2145 South Kedzie Avenue Chicago 23, Illinois


Cast Bronze is the most versatile, most adaptable bearing material available. With the facilities of the Bunting Foundry and Machine Shop plus Bunting Engineering, unusual bearing designs become possible. The Bunting Brass & Bronze Company, Toledo 9, Ohio. Branches in Principal Cities.
Bunting
PRECISION
BRONZE BARS.
BRONZE BEARINGS • BUSHINGS

MORE COMPLETE!
MORE USEABLE!
Your **NEW**
Electrical
Catalogs
are being distributed...



This unit, especially compiled for Product Engineers, is full of useful, up-to-date electrical product data for the highly important Original Equipment Market.

If it's *electrical* — make this your first source of information on **"Who", "Which"** and **"Where"** — it will save your time. *Get the ELECTRICAL CATALOGS habit . . . today!*

If not available at your plant, write to: Distribution Manager, McGraw-Hill Catalog Service. There is no charge to qualified users.

McGRAW-HILL PRE-FILED Electrical Catalogs

a Specific Market Unit of:

McGraw-Hill Catalog Service
330 W. 42ND STREET
NEW YORK 18, N.Y.

* *SINCE 1926* * *in the application, design and mfg. of pumps — separators — hydraulic accessories.*

cut "down time"

Remove Sludge and Dirt from Supply Lines with

KRAISSL SEPARATORS

SINGLE AND DUPLEX SEPARATORS — for both Standard and High Pressure operations — designed and engineered to give maximum protection to every supply line carrying diesel oil or lubrication oil — also steam lines; lubricating lines, cooling water service, and grease separators.

You can have any practical degree of separation — from primary straining to secondary filtration.

Baskets instantly and easily changeable— without tools. Magnet equipped type for lubricating lines, etc. — where metallic particles give trouble. Economical, too . . . Kraissl Separators entirely eliminate your normal filter replacement costs. The simple cleaning of Kraissl filter baskets restores original efficiency.

THE KRAISSL CO.
289 Williams Ave.
Hackensack, N. J.

Please send your bulletin A-1214 today to :

Name .....
Street .....
City ..... State .....

KRAISSL THE KRAISSL COMPANY, HACKENSACK, N. J.

289 Williams Ave.

Send for these...

ENGINEERING BULLETINS on SLEEVE BEARING DEVELOPMENTS!

YOUR BUSINESS LETTERHEAD REQUEST brings all back issues while still available — but write now!

Here's a quick, convenient way for the designer, engineer and draftsman to keep up-to-date on developments in materials, design and applications of sleeve bearings, bushings and similar precision parts. The latest news on improved cast and sintered copper-leads . . . the new bi-metal rolled, split-type bearings . . . the re-design problems involved when shortages call for bearing lining changes . . .

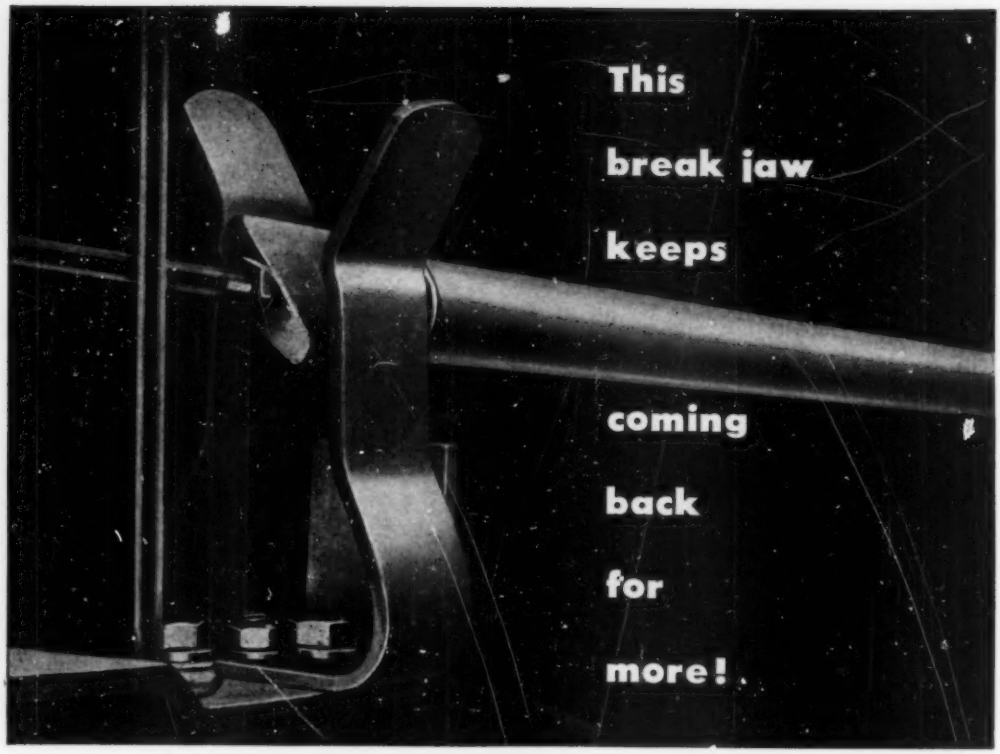
"Sleeve Bearing Topics" will help keep you abreast of all of these developments. A request on your business letterhead places your name on the list. Right now we can also send you back issues to make your file complete. Fits standard files, punched for a 3-ring binder. Address your request to:

FEDERAL-MOGUL CORPORATION
11043 SHOEMAKER • DETROIT 13, MICH.

FEDERAL-MOGUL

Since 1899

Our six plants produce sleeve bearings in all designs and sizes; cast bronze bushings; rolled split-type bushings; bi-metallic rolled bushings; washers; spacer tubes; precision bronze parts and bronze bars.



IT'S MADE OF BERYLCO BERYLLIUM COPPER

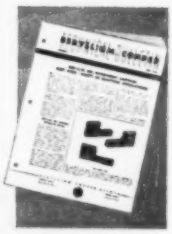
The break jaw shown here is an integral part of the Westinghouse V type disconnecting switch, designed for outdoor operation at 7½ to 230 kv, 400 to 2,000 amp. Why is it made of Berylco Beryllium Copper?

Because Westinghouse engineers wanted these qualities: good electrical conductivity; bulldog ability to grip the moving contact tightly, without relaxation, over a wide current range for long periods of time; enough "bounce" to withstand above-normal deflection without taking a permanent set.

Of all current-carrying materials, only Berylco 10 could meet these exacting demands. Furthermore, Berylco's unique combination of high conductivity and high elasticity made it possible to design the break jaw in one piece. Construction was thus simplified, efficiency of operation improved.

The unique properties of this versatile alloy —its combination of great strength, electrical conductivity and resistance to fatigue— are as vital in the products of defense as they are in peacetime products. We invite you, in your plans for the future, to take advantage of the technical knowledge of the world's largest producer of beryllium copper.

VALUABLE ENGINEERING INFORMATION on Berylco Beryllium Copper is compiled in a series of monthly technical bulletins. To receive your copy regularly, write on your business letterhead.



Sample material is available for testing purposes.

Tomorrow's products are planned today —with Berylco Beryllium Copper.

BERYLCO THE BERYLLIUM CORPORATION

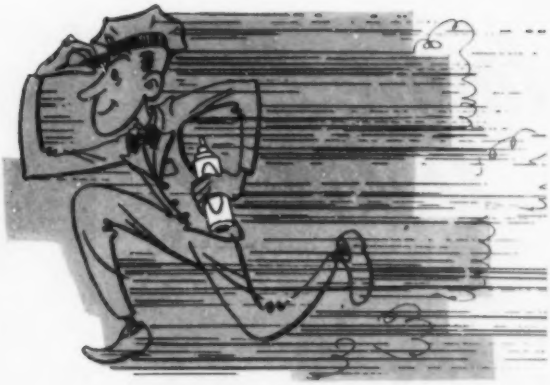
DEPT. I, READING 2, PENNSYLVANIA

New York • Springfield, Mass. • Cleveland • Dayton • Detroit • Chicago • Minneapolis • St. Louis • Seattle • San Francisco • Los Angeles

Representatives in principal world-trade centers

YOU GET

PROMPT DELIVERY plus . . .*



WHEN YOU SPECIFY **O-M** CYLINDERS

* ***MORE POWER IN LESS SPACE AT LOW COST***

—as provided by these talked-about features:

Compact Performance

Simplified design eliminates tie-rods and bulky end caps. Saves up to 1/3 space when installed.

Flexible Performance

Interchangeable mounting brackets may be fitted without disassembly. Pipe Ports adjustable to any angle. Easily disassembled and re-packed.

Low Cost Performance

Lower first cost . . . smaller inventory . . . minimum maintenance.

FREE TEMPLATES

For the first time in the industry, O-M offers a complete set of templates showing all cylinders and mounting brackets. ½ scale. Your set on request.

O-M manufactures:

- **Air**
- **Water**
- **Hydraulic**

Cylinders

In full range of sizes from 1½ to 8" bores. All machined steel and bearing bronze.

ORTMAN-MILLER
MACHINE COMPANY, INC.

1222 - 150th Street, Hammond, Indiana

Immediate Delivery

on these AIR VALVES

...because we planned our 1950 production facilities with 1951 in mind!

Write, Wire or Call Today!

TESTED – PROVEN – ACCEPTED!

CHOOSE THE

AIR VALVE YOU HELPED DESIGN

Best for Trigger-Quick Control of All Air Operated Equipment

• FULL FLOW • COMPACT • ONE MOVING PART

CAM VALVE

PILOT CONTROLLED VALVE

FOOT VALVE

DOUBLE SOLENOID VALVE

SOLENOID VALVE

TWO PRESSURE VALVE

Send for FREE Catalog

MAC

MECHANICAL AIR CONTROLS, INC.

15315 W. 11 MILE RD. • ROYAL OAK, MICHIGAN

Preferred where performance is paramount

A. W. HAYDON

D. C. TIMING MOTORS

with Chronometric Governor

A primary power source of extreme accuracy, this revolutionary development of the A. W. Haydon Company is the first successful production combining the accuracy of a clock with the power of a motor. Made with jeweled movements, this extraordinary timer permits the solution of problems heretofore considered insurmountable.

Special Features:

- Extreme accuracy
- Wide range of voltage, load and temperature
- Reversible
- Compact
- Light weight

Write Today for catalog sheet giving full information of A. W. Haydon D.C. Timing Motors with Chronometric Governors.

The A.W. HAYDON COMPANY

221 NORTH ELM STREET

WATERBURY 20, CONNECTICUT

Design and manufacture of Electrical Timing Devices

HARD CHROME PLATING

25,000 Amp. Generator capable of handling

Lengths up to 62 feet long

• • •

SMALL PARTS A SPECIALTY

• • •

ANODIZING COMPLETELY EQUIPPED

Government Specifications

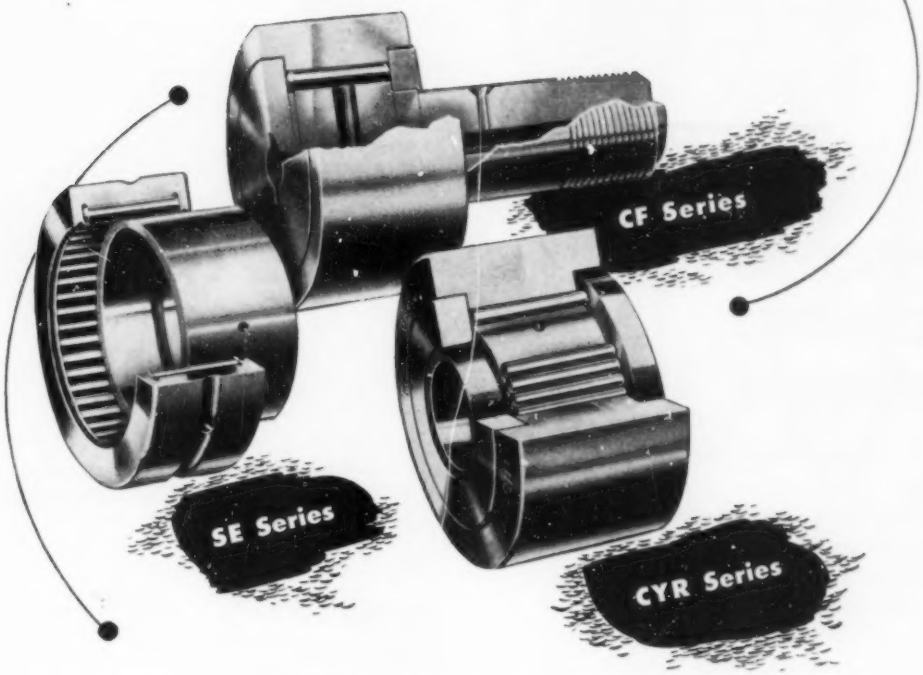
PROMPT AND GUARANTEED SERVICE

HARDCHROMERS, INC.

Krick Road Bedford, Ohio

Telephone Bedford 2-1500

MULTIROL precision is PERMANENT



The fine precision originally built into every McGill Multirol Bearing actually lasts longer. It can easily be considered permanent by comparison because Multirol Bearings are free from early internal wear that can destroy the accuracy of friction type bearings.

The rolling action of small diameter rollers maintaining a constantly lubricated roller line contact with raceways makes the difference — keeps the Multirol Bearing equipped machinery operating at top efficiency without costly maintenance for frequent adjustments and bearing replacement.

For the increased production demands just ahead you will need the performance extras of McGill Multirol Bearings. Adopt the SE Series for precision handling of increased loads when radial space is limited. Either the CF Series with stud or the CYR Series for shaft mounting will withstand heavy shock load in any kind of cam action application. Write today for descriptive Multirol® Bearing Bulletins.

McGILL MANUFACTURING CO., INC.
BEARING DIVISION,
201 N. LAFAYETTE ST.,
VALPARAISO, INDIANA, U. S. A.

McGILL® precision bearings

The lugs beneath the heavy flanged section of the transformer terminal shown above are designed to prevent rotation of the part after installation. The sharply defined corners required in this part were produced by Scovill cold heading and accomplish exactly what the designer intended.

Scovill makes a specialty of tough cold heading jobs—has the engineers, toolmakers and operators to turn out parts like these *exactly* the way you need them. Send your sample or blueprint for further information.

"Guide to the Profitable Use of Cold Heading"—Bulletin No. 2 describes the advantages and limitations of this process for the designer. It's free for the asking.

RECESSED HEAD SCREWS • SEMS • TAPPING SCREWS
STANDARD MACHINE SCREWS • SPECIAL COLD HEADED PARTS

SCOVILL FASTENERS AND SPECIAL PARTS

INDUSTRIAL FASTENER SALES, WATERVILLE DIVISION
SCOVILL MANUFACTURING CO., WATERVILLE 14, CONN.
Montclair, N. J. • Detroit • Wheaton, Ill. • Los Angeles • Cleveland • San Francisco

High-Speed Counting Problems?

Berkeley DECIMAL COUNTING UNITS

★ **HIGH SPEED**—Different models provide maximum continuous counting speeds of 30,000, 100,000 or 1,000,000 counts per second. Resolution down to 1 microsecond.

★ **DIRECT READING**—Decimal count is indicated directly by illuminated numbers on front panel.

★ **INTERCHANGEABLE**—Plug in mounting with standard octal base for easy interchangeability. Decimal counting units are complete in themselves, ready for incorporation as a basic component for electronic counting equipment.

★ **RUGGED, COMPACT**—Components mounted in sturdy plastic moulding, moisture and fungus-proofed; enclosed in stamped aluminum case only 1-3/16" wide by 5⅜" high by 5¾" deep (including tubes).

★ **CAPACITY**—Output of one unit will drive following unit (or relay-operated mechanical register). Any number of DCU's may be mounted in cascade to provide counting bank of desired capacity.

For complete data, please write Dep't. D.

Berkeley Scientific Corporation
2200 WRIGHT AVE. • RICHMOND, CALIF.

3-WAY 4-WAY PILOT-OPERATED VALVES

Short Solenoid Strokes Permit High Operating Speeds with Full Volume Operation

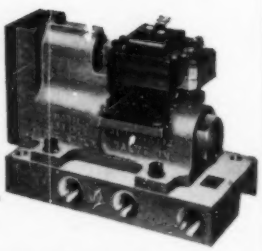
RUGGED CONSTRUCTION FOR HEAVY DUTY OPERATION

•

CYCLING TO 600 PER MIN.

•

FOR CONTROL OF COMPRESSED AIR-PRESSURES 20 TO 150 LBS.



Available in standard pipe sizes.

Thousands of AUTOMATIC 3-way and 4-way valves in daily operation. Write for bulletin and prices. Attractive quantity and O.E.M. discounts.

AUTOMATIC VALVE CO.
37423 GRAND RIVER AVE., FARMINGTON, MICH.

PIONEERS and SPECIALISTS in PILOT OPERATED SOLENOID CONTROLLED VALVES

Why pussyfoot in picking tubing?

Bundyweld Tubing, double-walled from a single strip. Exclusive, patented beveled edge affords smoother joint, absence of bead, less chance for any leakage.

No need to get yourself out on a catwalk when it comes to choosing a small-diameter tubing for your product.

Bundyweld, the multiple-wall type of Bundy® tubing, is top choice across the boards for applications ranging from radiant heating grids and automotive pressure lines to cartridges of ball-point pens. The only tubing that's double-walled from a single strip, Bundyweld is made by the world's largest producer of small-diameter tubing.

For technical help or information, contact Bundy Tubing Company today.

Bundy Tubing Company

DETROIT 14, MICHIGAN

World's largest producer of small-diameter tubing

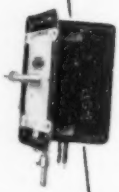
AFFILIATED PLANTS IN ENGLAND, FRANCE AND GERMANY

DESIGNING FOR DEFENSE?

UTILIZE COMPACT

SYNCHRON
TRADE MARK

TIMING MOTORS
TIMING MACHINES
CLOCK MOVEMENTS
D. C. MOTORS



POWERFUL, PRECISE SYNCHRONOUS MOTORS

SYNCHRON synchronous motors meet your requirements for compact power. Pulls up to 8 oz. direct load continuously at 1 R.P.M. Gear trains can be furnished to convert to any speed. Unusual actions can be incorporated in movement. Our engineers will be glad to work with you in developing motors for special applications.

Hansen D.C. motors powered servo units which won Army-Navy E. Used also in aircraft instruments and radio control mechanisms.

Send NOW!

HANSEN
MANUFACTURING COMPANY INC.
PRINCETON, INDIANA

PLEASE SEND ENGINEERING DATA ON:

- ☐ SYNCHRON TIMING MOTORS
- ☐ SYNCHRON TIMING MACHINES
- ☐ SYNCHRON CLOCK MOVEMENTS
- ☐ MAGNA-TORC DIRECT CURRENT MOTORS

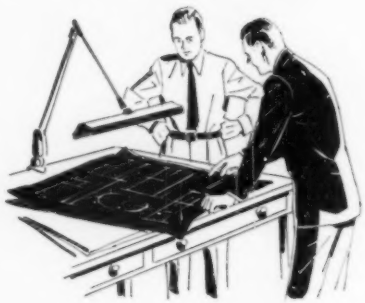
NAME .....

FIRM .....

ADDRESS .....

CITY ..... STATE .....

If you are looking for an Answer to a Special Carburetion Problem...



You are looking for

Zenith

Zenith's skill and experience have always been concentrated to one particular end—to provide the finest in specialized carburetion. Through the years Zenith has dealt with every type of engine—ranging from single cylinder lightweights to the most rugged and powerful of gasoline engines—applying 25 years of experience to the mastery of almost every conceivable carburetor problem. In engineering the individual carburetor to the specific requirements of the job, questions of placement, efficiency of performance, and economy of operation are considered from blueprint to production stage. If you are looking for the answer to a particular carburetion problem, you are looking for Zenith. Inquiries will receive prompt attention.

ZENITH CARBURETOR DIVISION OF
696 Hart Avenue
Detroit 14, Michigan
Bendix AVIATION CORPORATION

MANUFACTURERS OF FINE CARBURETORS AND FUEL FILTERS

Export Sales: Bendix International Division, 72 Fifth Avenue, New York, 11, N. Y.

Since the OBERDORFER INTERNATIONAL Pumps described below are new, with no prior history of use, Washington expects a DEFENSE ORDER or equivalent for their purchase. Free samples are available to O.E.M. accounts.

Introducing

The New Series 2

OBERDORFER INTERNATIONAL

BRONZE Close Coupled ROTARY GEAR PUMPS

For liquid transfer where space is at a premium . . .

OBERDORFER
Bronze spur gears (Oberdorfer alloy #16438)
2 Mechanical pressure and suction seals
Carbon bearings (oilless)
Bronze housing (Oberdorfer alloy #16001)
2 Micro finished stainless steel shafts

These two motor driven pumps have all-bronze housing and gears, oilless carbon bearings, micro-finished stainless steel shafts (± 25/100,000 of an inch) and are powered by heavy-duty ⅓ h.p. motors* equipped with thermal overload protection.

They are intended to be used wherever a liquid has to be moved from one location to another in quantities up to 240 gallons per hour at pressures from 0 to 100 lbs. per square inch.

They are adaptable for a wide variety of industrial and chemical applications where a corrosion-resistant pump is required and space is limited. Their all-bronze body and gears permit use with most liquids.

* 110 volt AC, Motor standard but specially machined for pump mounting.

DIMENSIONS—Pump Only

Pump No.	Height	Width	Length
No. 1½	2⅞	2⅞	4¾
No. 2	3⅛	2⅜	4⅞

GALLONS PER HOUR at 1725 R.P.M.

Pressure	Pump No. 1½ CCC	Pump No. 2 CCC
0 lbs.	120 gal.	240 gal.
25 lbs.	110 gal.	220 gal.
50 lbs.	100 gal.	190 gal.
75 lbs.	95 gal.	170 gal.
100 lbs.	90 gal.	——

PUMP No. 1½ CCC

Pump head only (⅛" pipe size).....list $20.00
F.O.B. Syracuse
Complete unit with ⅓ H.P. 110 volt AC thermal overload motor.....price on request

PUMP No. 2 CCC

Pump head only (⅜" pipe size).....list $22.50
F.O.B. Syracuse
Complete unit with ⅓ H.P. 110 volt AC thermal overload motor.....price on request

Write Dept. PE-519

INDUSTRIAL PUMP DIVISION
Oberdorfer Foundries, Inc.
Syracuse, N. Y.

STOW

goes into the mines with the men

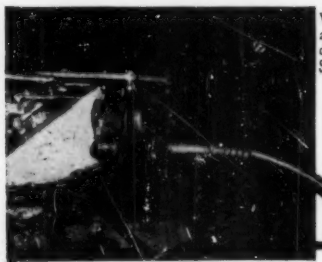
flexible shaft application developed by the Crichton Co., Johnstown, Pa.

TO ELIMINATE DANGER . . . of explosion or electric shock while drilling in wet or gassy mine conditions.

TO SPEED PRODUCTION In use figures prove that this flexible shaft application has increased production by more than 25%.

TO CUT COSTS The light weight and high speed of this unit make economical one-man operation possible.

STOW CAN HELP SOLVE YOUR POWER TRANSMISSION PROBLEMS, TOO!



Write today for catalog and complete engineering data on STOW Flexible Shafting.

STOW MANUFACTURING CO.
426 State Street
Binghamton, N. Y.

Spincraft

SKILL WILL DO IT

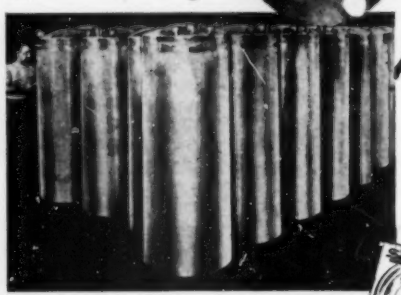
Production Methods Help You Gain Months of Time

Costs are *much lower*, too

Whenever emphasis is on speed in delivery, or lower costs, consider Spincraft metal fabricating. Of all the methods available for cold shaping flat or rolled sheet metals, the spinning lathe, plus special Spincraft forming skills, offers the fastest and least expensive means of getting production rolling. As an example, consider the parts and assembly for the water sterilizer unit illustrated here. From a scratch start Spincraft made the required tools, produced the components and assembly and began delivery ten days after receipt of the order. Months of time were gained, thousands of dollars saved.

Cases like this are everyday experiences at Spincraft — on both small and large runs. The answer you want cannot be guaranteed, but others have been helped so often and so well that Spincraft has become the world's largest metal spinning and fabricating plant. Call or write

Components for stainless steel water sterilizer—spun, fabricated and assembled in record time at lowest cost.



The function, scope, mechanics and economics of Spincraft metal spinning and fabricating are discussed in this stimulating 40-page, well-illustrated booklet. A copy is yours for the asking.

Spincraft
SKILL WILL DO IT
INCORPORATED

4139 W. STATE ST.
MILWAUKEE 2, WIS.

Heretofore known as
Milwaukee Metal Spinning Co.

VOLTAGES?
HEAT LOSSES?
SWITCHES?

Need fast answers on *Electric Heat?*

TEMPERATURE?
CONTROLS?
RELAYS?
ALLOWABLE HEAT UP TIME?
TERMINALS?
VOLTAGES?

FOR WAFFLE BAKERS?

FOR WING GUNS?

Relax—you can get them simply by taking advantage of the experience of our engineers. Chances are good that the answer you need is already in our files. If it isn't, we'll get it for you—in a hurry!

We have a wealth of information on heating problems—information it might take you weeks or months or even years to develop on your own. That's because we're specialists at engineering and controlling electric heat. Our men work at it every day . . . for many different manufacturers . . . of many different products.

As a result, we're uniquely qualified to help you—on both civilian production and defense contracts. You'll find TK* Heating Units in everything from waffle bakers to butter warmers, roasters to defrosting apparatus, teakettles to flatirons.

And, as we proved in World War II, we're equally at home with heating elements for guns, gun directors, instrument panels, boat galleys and a host of other aircraft, marine and submarine applications.

So, when you need fast answers, turn your electric heating questions and problems over to us. Rest assured they'll be in good hands!

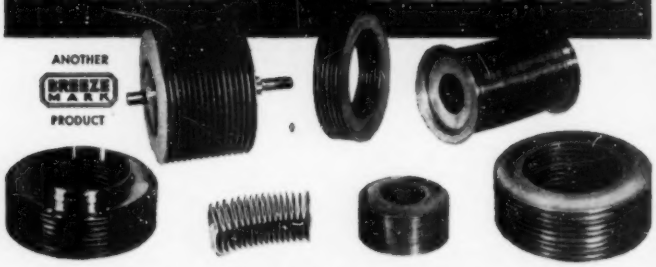
TK *Heating Units*

*T. M. REG. U. S. PAT. OFF.

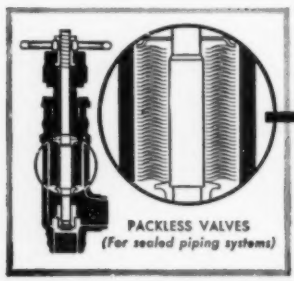
TUTTLE & KIFT, INC. 1623 N. MONITOR AVE., CHICAGO 39, ILLINOIS
A SUBSIDIARY OF FERRO ENAMEL CORPORATION

MOISTURE SURFACE UNITS • OVEN UNITS • TK INFINITE CONTROL • SWITCHES & SELECTORS • WATER HEATER UNITS • PLATIRON UNITS • INDUSTRIAL UNITS

BREEZE Job-Engineered BELLOWS



...Give LASTING PROTECTION Where Ordinary Bellows Fail



Breeze welded diaphragm bellows meet the operating life cycle of any equipment in which they are used *because every Breeze bellows design is individually engineered and built for the job.*

Breeze has no "stock bellows," but if you have a vibration problem in ducts, large or small, or want permanently sealed valve enclosures in any type of piping system, or need bellows for torque transmission or other uses, Breeze experience can quickly provide the answer . . . and production can meet your requirements.

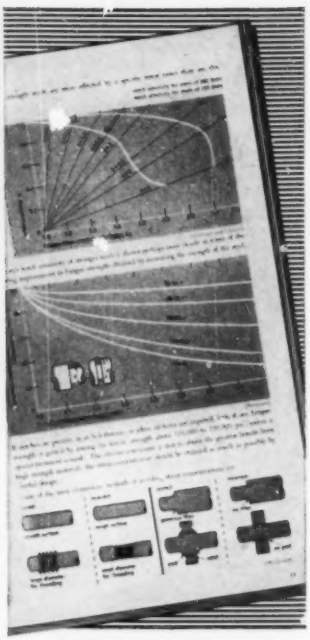
A Breeze bellows is dependable because each diaphragm is designed to work well within its elastic limit. This is accomplished by thorough analysis of each application and careful design of the bellows to withstand all requirements. "Job engineering" each individual type eliminates makeshifts, assures efficient performance.

Breeze bellows are made in stainless steel, inconel, monel, nickel, steel, or other weldable alloys.

Feel free to consult us without obligation on your existing bellows requirements, or any other project where reliable welded diaphragm type bellows might solve a design problem.

BREEZE
CORPORATIONS, INC.
41-R South Sixth Street, Newark 17, N. J.

OTHER BREEZE PRODUCTS: ACTUATORS · RADIO SHIELDING · AERO-SEAL HOSE CLAMPS



Every designer must be something of a metallurgist

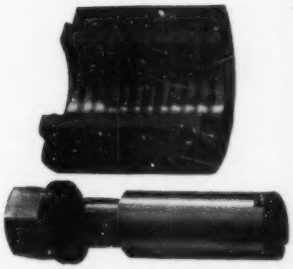
Here are 72 pages packed with information of vital significance to engineers faced with the design, selection and treatment of steel components to give a specified service at minimum cost.

Besides dealing with scientific design, the book gives important metallurgical data, all compiled from the designer's viewpoint. Free on request.

Climax Molybdenum Company
500 Fifth Avenue · New York City

Please send your
FREE BOOKLET
3 KEYS TO SATISFACTION

Name .....
Position .....
Company .....
Address .....
PE. 9 F22



SPECIAL AJAX NEOPRENE BUSHED FLEXIBLE COUPLINGS FOR EXACTING NEEDS

Processing Plants Reduce Down-Time

Availability of Neoprene Bushings on Ajax Flexible Couplings is an aid to men in chemical, petroleum and other processing industries.

The use of Neoprene Bushings combines the advantages of Ajax resilient, yet positive drive with the chemical resisting characteristics of Neoprene.

Design engineers have learned to automatically think of Ajax Couplings as the standard. Their 30-year performance record is proof of their ability to safeguard bearings, gears, armatures, impellers and other costly working parts.

Ajax engineers, both in the factory and in the field, welcome the opportunity to work hand-in-hand with the men responsible for design and installation of direct-connected machines. Ajax Flexible Couplings are available in standard, bolt-on, brake drum and other types to fit most applications. Write for Bulletin 48.

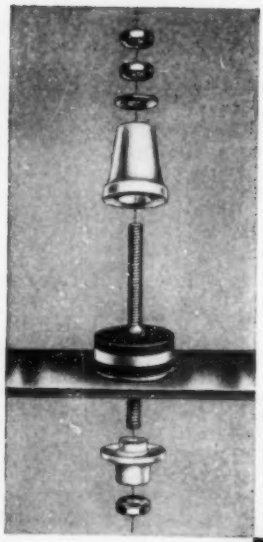
AJAX

KNOWS COUPLINGS

Working Hand-in-Hand With America's Leading Manufacturers and Users of Direct-Connected Machines for Thirty Years...

AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD, NEW YORK



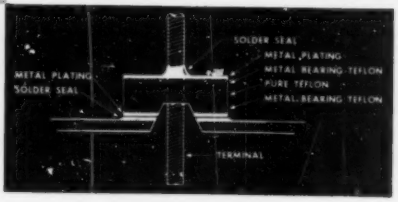
first again with

TEFLON

•

HERMETICALLY SEALED TO METALS

(Patents Pending)



for Vacuum-tight TERMINALS and FEED-THROUGH INSULATORS

for Moisture-impervious PRINTED CIRCUITS

for Electrical characteristics ranging from insulator to semi-conductor to low resistance conductor in the same unit.

for Metal Faced Teflon sheets, bars, cylinders and certain fabricated parts for particular problems.

The fluoro-carbon metal fused seal is a true hermetic seal capable of holding a vacuum for sustained periods. It is recommended where severe service conditions are encountered—vibration, shock, high and low ambient temperatures, thermal shock, extreme climatic conditions.

Because Teflon is being allocated by the Government, only those problems which bear National Production Authority Sanction can be considered at this time.

For further information, write.

UNITED STATES GASKET COMPANY

TEFLON PRODUCTS DIVISION

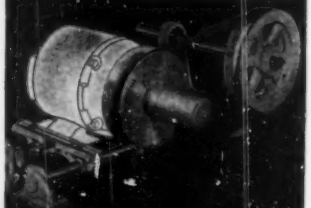
649 N. 10TH STREET, CAMDEN, N.J.

WANTED! Speed-Change PROBLEMS

GERBING

ROTO-CONE

Complete VARIABLE SPEED DRIVES



- Variable Speed Pulleys
- Adjustable Motor Bases
- Countershaft Bases
- V-Belts
- V-Driven Sheaves

Here's the "Why" of Roto-Cone's Superiority...

V to V DRIVE sizes ⅛ to 15 h.p.

UP TO 4 to 1 Speed-Change Ratio

Straight Line Base Adjustment

Here is Industry's most versatile speed control drive. Rack and pinion arrangement, *exclusive* in Roto-Cone, provides equal and opposite lateral movement of both discs, therefore V-belt *always* travels on a fixed center line. Result is maximum, vibrationless transmission of power and full belt life. No expensive angular base mounting required.

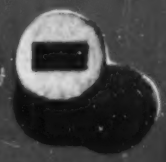
Write for details and the assistance of our speed control engineers.

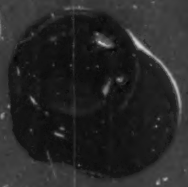
GERBING MFG. CORP.

Dept. G, NORTHBROOK, ILL.

(Suburb of Chicago)

ADVANCE HAS THE RIGHT COMBINATION FOR TOUGH PRESSURE CASTINGS





Leading manufacturers turn to ADVANCE PRESSURE CASTINGS for the solution of their special casting problems.

Working together with Eagle Lock Co. engineers, our own staff tackled the intricacies of the various castings required for the many types of Eagle locks. The result . . . such special castings as plugs with wafer slots cored right in; cast dials complete with numbers; multi-impression dies used on all parts with complete interchangeability of ALL impressions making for LOW piece price and LOW assembly costs.

Another triumph for the adaptability of die castings, Eagle locks are primary evidence of the advantages offered by ADVANCE PRESSURE CASTINGS with its own complete facilities, from blueprint to finished product.

Whatever your problem, consult with ADVANCE PRESSURE CASTINGS for your proper combination—without obligation, of course.

ADVANCE PRESSURE CASTINGS Inc.

20-30 Wythe Ave., Brooklyn 11, N. Y.

ALLIS-CHALMERS'

Country-Wide Engine Service

Now **MORE IMPORTANT** than ever!

A-C ENGINE SERVICE . . .
As Close As Your Phone

There's service nearby for every Allis-Chalmers engine through the thousands of authorized A-C dealers—helping assure continued operation of equipment in coming times of critical shortages. This convenient service builds user satisfaction, greater acceptance for your products when they are driven by A-C Power Units.

Designed for tough tractor service, these heavy-duty engines build customer satisfaction through performance, too. They [illegible] high in torque, hang onto overloads. Users also like the low first cost — due to mass production — as well as the economical operation and low upkeep.

Investigate these dependable Allis-Chalmers Power Units for your own products. Our engineers will gladly work with you in selecting the unit for your requirements.

A MODEL TO FIT Your Needs

MODEL*	R.P.M.	MAXIMUM BRAKE HP.
B-125	1500-1800	24.5-28.0
W-201	1400-1800	33.5-40.5
U-318	1200-1400	45.0-50.9
E-563	1050	74.0
L-844	1050	110.0

*Figures represent cu. in. piston displacement.

Accessories to fit applications. Choice of fuels.

ALLIS-CHALMERS
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

the right answer

. . . to every gauge need IN THIS NEW CATALOG

The right answer—the Marsh answer — to every pressure gauge need is described by this new Marsh catalog which covers hundreds of variations of styles, types, mountings, ranges, functions. Remember that Marsh gauges, from the "Standard" series line to the heavy-duty "Mastergauge" series have proved across the years to be the most economical you can buy for a given set of conditions. Let us prove this in terms of gauges for your product.

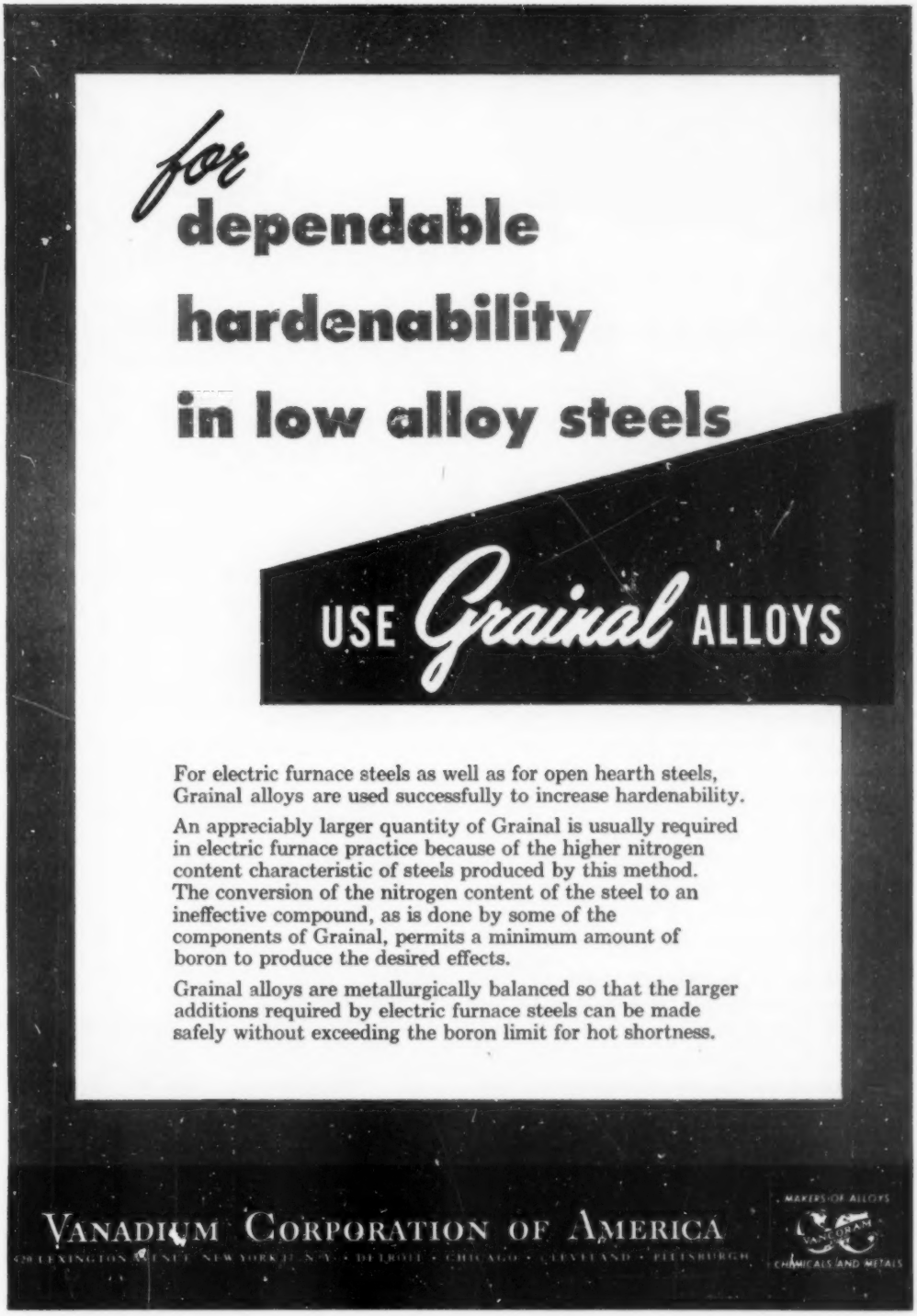
MARSH INSTRUMENT CO.
Sales affiliate of
Jas. P. Marsh Corp., Dept. 39, Skokie, Ill

LEAKE *Creative* METAL STAMPINGS

The LEAKE Organization offers designing and engineering service with complete production facilities for stampings of any size or shape from carbon or alloy steels, magnesium or aluminum alloys, copper or brass alloys, and stainless or monel metals. Press capacities up to 2500 tons . . . mechanical or hydraulic.

Literature available . . . WRITE!

THE LEAKE STAMPING COMPANY
MONROE, MICHIGAN


for
dependable
hardenability
in low alloy steels
USE Grainal ALLOYS
For electric furnace steels as well as for open hearth steels, Grainal alloys are used successfully to increase hardenability.
An appreciably larger quantity of Grainal is usually required in electric furnace practice because of the higher nitrogen content characteristic of steels produced by this method. The conversion of the nitrogen content of the steel to an ineffective compound, as is done by some of the components of Grainal, permits a minimum amount of boron to produce the desired effects.
Grainal alloys are metallurgically balanced so that the larger additions required by electric furnace steels can be made safely without exceeding the boron limit for hot shortness.
VANADIUM CORPORATION OF AMERICA
MAKERS OF ALLOYS
VANADIUM
CHEMICALS AND METALS

ALL PEERLESS MOTORS ARE "Peerless Registered"

MORE than 90% of all Peerless Motors are custom manufactured to meet the specific operating requirements of the equipment with which they are to be used.

So we "Peerless Register" every motor before shipment. The words "Peerless Registered" are a trademark, recorded in the U. S. Patent office. Only Peerless Motors can bear this phrase, and only Peerless Motors offer you this protection.

This registration record is assurance to both you and your customer that the Peerless Motor has been properly designed for your equipment so as to give best possible performance and long, satisfactory service. And the registration record makes possible the quick identification of any Peerless Motor—anywhere.

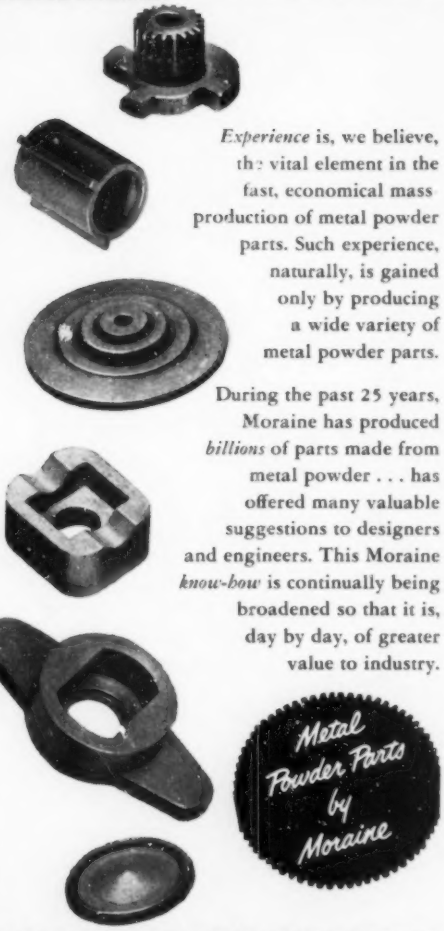
THE PEERLESS ELECTRIC CO., WARREN, OHIO

Manufacturers of Quality Motors Since 1893

Single Phase • Polyphase • Direct Current • ¼ to 15 H.P.

ALL *Peerless Motors* ARE "PEERLESS REGISTERED"

DESIGNED RIGHT... EXACTLY PRODUCED



Experience is, we believe, the vital element in the fast, economical mass production of metal powder parts. Such experience, naturally, is gained only by producing a wide variety of metal powder parts.

During the past 25 years, Moraine has produced *billions* of parts made from metal powder . . . has offered many valuable suggestions to designers and engineers. This Moraine *know-how* is continually being broadened so that it is, day by day, of greater value to industry.

Metal Powder Parts by Moraine

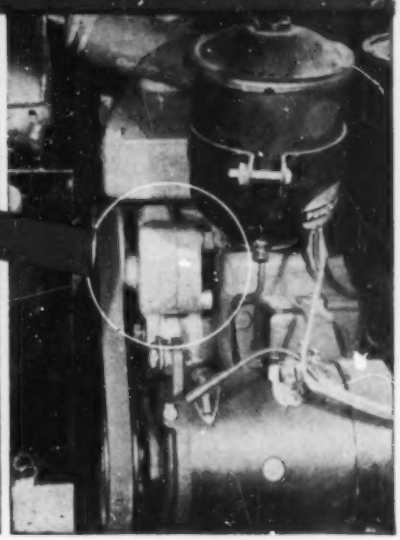
MORAINE PRODUCTS

DIVISION OF GENERAL MOTORS, DAYTON, OHIO

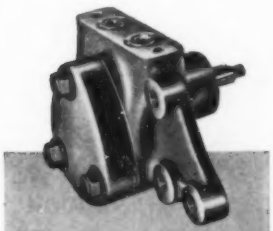
Another Job for Pesco HYDRAULIC MUSCLES

BW

"The sensitive response of the hydraulic system permits such trigger-fine adjustment that operators are loud in their appreciation," says Massey-Harris . . . *the sales power of hydraulic power in action.*



Circle shows position of Pesco pump.



Pesco pump designed for Massey-Harris Pony tractor. Capacity: 2.5 g. p. m. @ 2880 r. p. m. @ 1000 p. s. i.

Pesco *Dual Purpose* Pump Eliminates Extra Power Shaft on Massey-Harris Pony

The problem was to eliminate all unnecessary weight and cost and save space on a small tractor.

So Massey-Harris tractor engineers and Pesco hydraulic engineers teamed up . . . together came up with a specially designed dual purpose hydraulic pump to serve as both pump and fan bearing mounting.

Result: less space and weight required . . . necessity for an extra motor power shaft is eliminated.

Such teamwork between Pesco and client engineers is frequent. Matching hydraulic know-how and skills with the engineering knowledge of a manufacturer's engineering staff is the way we at Pesco like to work. It is teamwork that puts the sales power of hydraulic power to work to full advantage for our customers.

If you have a problem in hydraulics Pesco engineers will gladly co-operate with your engineers to solve it. Write today.

engineering Pesco production

PRODUCTS DIVISION

BORG-WARNER CORPORATION

24700 NORTH MILES ROAD BEDFORD, OHIO

. . . IN PRECIOUS METAL AND PRECIOUS METAL-CLAD . . WIRE . . TUBING . . FLATSTOCK . . CONTACTS . . OR WAVE GUIDE?

UNION PLATE AND WIRE CO.'S LIFETIME OF EXPERIENCE IS AT YOUR COMMAND

Our Industrial Division is daily solving many of the engineer's problems for contacts, contact materials, collector rings, small fabricated parts in both precious metals and precious metal-clad as well as composite base metals. Intimately bonded alloys permit you to use the many advantages of precious metals without sacrificing the desired physical and mechanical properties of the base metals.

EVERYTHING custom made to YOUR specifications and YOUR tolerances. Nothing "Off the Shelf". So you no longer have to FISH for quality. A letter of inquiry to our engineers, stating your problems will bring you a prompt reply.

UNION PLATE AND WIRE CO.
65 Union Street, Attleboro, Mass.

NEW YORK OFFICE: 30 Church St., New York 7, N. Y. • CHICAGO OFFICE: Room 1201, 55 E. Washington St., Zone 2.

QUALITY-CONTROL HANDBOOK

Just Published!

1. A reference of industrial know-how on the fundamentals and means of achieving *better product quality at lower cost.* Use it for basic or advanced review of all phases, not only the statistical, of the quality-control function—for quick reference to many formulas, data, record forms, and other practical information. Covers economics of quality control; organization for quality; acceptance, control, and assurance of quality; application to specific processes and products. Every section the work of specialists; illustrative examples from actual cases and records offer practical working information. **Edited by J. M. Juran, Consulting Management Engineer. 768 pp., 6 x 9, 176 illus., $10.00**

MATHEMATICS FOR ENGINEERS

New 3rd Edition
Just Published!

2. An outstanding quick reference book for engineers. Covers every phase of mathematics the engineer is likely to meet, from algebraic notation, determinants, and linear equations through differential calculus, curve analysis, integration, summation, etc. Many graphical explanations and illustrative examples aid in understanding and application. Revised Third Edition contains much added material, including chapters on Differential Equations and Dimensional Analysis, with special emphasis given to the Buckingham Pi theorem. **By Raymond Dull and Richard Dull, Engineer, Webster-Chicago Corp. Third Edition. 822 pp., 5½ x 8, illustrated, $7.50**

DESIGN OF MACHINE MEMBERS

New 3rd Edition—Just Published!

3. Explains the theory, together with the practical applications, of designing the various elements in operating machines. Discusses engineering materials, factors of safety, utilization factors, the selection of design stresses, etc. Covers developments in such machine parts as riveted joints; power screws; spur, bevel, and screw gears, etc. **By Alex. Valiance and Vernon L. Doughtie, Prof. of Mech. Eng., Univ. of Texas. 500 pages, 346 illus., $6.00**

MATERIALS HANDBOOK

New 7th Edition—Just Published!

4. Presents the most pertinent and important facts relating to more than 8800 materials to enable executives, purchasing agents, and engineers to make comparison, avoid checking many sources, and quickly get a working knowledge of the best suited materials for a particular purpose. Gives detailed information on chief characteristics, comparative data, sources, substitutes, adulterants, and uses for each material. Includes a section on important economic geography. **By George S. Brady. 7th Edition, 879 pages, $8.50**

SEE THESE BOOKS 10 DAYS FREE

McGraw-Hill Book Co., 330 W. 42nd St., N.Y.C. 18

Send me book(s) checked below for 10 days' examination on approval. In 10 days I will remit for book(s) I keep, plus few cents for delivery, and return unwanted book(s) postpaid. (We pay for delivery if you remit with this coupon; same return privilege.)

- ☐ 1. Juran—**Quality-Control Handbook** $10.00
- ☐ 2. Dull—**Math for Engineers** $7.50
- ☐ 3. Valliance & Doughtie—**Mach. Mem** $6.00
- ☐ 4. Brady—**Materials Handbook** $8.50

Print
Name .....
Address .....
City ..... Zone .... State .....
Company .....
Position PE-9

This offer applies to U. S. only.

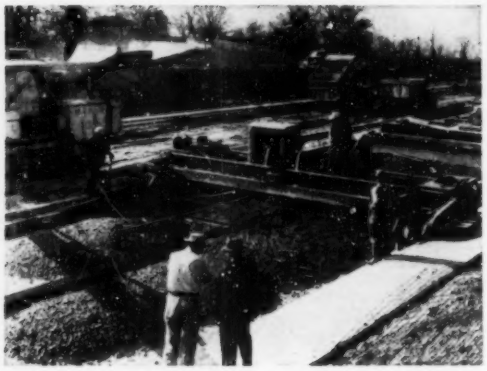
For precision and dependability look to Kollsman

KOLLSMAN INSTRUMENT CORPORATION

Elmhurst, New York • Glendale, California

BIG NAMES

in road building and maintaining



all use BLOOD BROTHERS Universal Joints for a solid reason

J. D. Adams Mfg. Co.	Huber Mfg. Co.
Barber-Greene Co.	The Jaeger Machine Company
Braden Winch Co.	Meili-Blumberg Corp.
Brooks Equipment Co.	W. A. Riddell Corp.
Caterpillar Tractor Co.	Seaman Motors
E. D. Etnyre & Co.	Tulsa Winch Division of Vickers, Inc.
The Galion Iron Works & Mfg. Co.	Koehring Company
Frank G. Hough Co.	

From simple joints for shafts turned by hand wheels — to finely balanced precision propeller shafts—road building equipment requires universal joints of almost every type. Many of them take a high-speed, power-packed beating on giant trucks... tractors... and complex paving machines.

But be they big or small, where you find universals on road building equipment, you'll usually find BLOOD BROTHERS' name. The reason is simple — and solid. BLOOD BROTHERS Universal Joints are engineered and built to deliver what the job requires — with a wide margin to spare — through years of use.

Whether its road building machinery or another line — if you use universals, you may find it advantageous to consult with BLOOD BROTHERS' engineering staff. Write for catalog and information.

BLOOD BROTHERS machine co.

A Division of Standard Steel Spring Co.

ALLEGAN, MICHIGAN

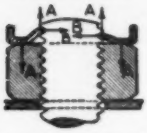
Chicago Office: Great Lakes Spring Division, 7035 West 65th Street

---

ABSOLUTE SECURITY for BOLTED ASSEMBLIES

—regardless of VIBRATION *or* **LOAD**

Ordinary nut carries the load — PALNUT keeps it tight with DOUBLE-LOCKING SPRING ACTION



Powerful spring tension (A-A) is exerted upward on the bolt threads and downward on the ordinary nut, while slottedjaws(B-B) close in and grip the bolt like a chuck. Nut can not loosen—bolt can not back out.

Write for samples and literature

THE PALNUT COMPANY

65 Cordier St., Irvington 11, N. J.

PALNUT Trademark **LOCK NUTS**

Leach RELAYS

Precision is the Keynote—in Production and Performance

The word precision perfectly characterizes every relay manufactured by LEACH, and this precision is most apparent in their performance. Whatever the purpose, LEACH can provide relays of advanced design for flexibility, economy and unexcelled performance. Highest standards of engineering, materials and workmanship. For better controls through better relays—contact LEACH.

LEACH RELAY CO.

5915 AVALON BOULEVARD, LOS ANGELES 3, CALIF.

Representatives in Principal Cities of U. S. and Canada

MEMO

To: users of A.C. adjustable Speed Drives

From: THE LOUIS ALLIS CO.

50th YEAR

Only SELECT-A-SPEDE

offers the NEW MAGNETIC AMPLIFIER CONTROL with superior performance at no extra cost!

Easy to install and operate • Simple circuits, easy to maintain • Compact design saves floor space

POWER UNIT
OPERATOR'S CONTROL STATION
Any speed you select at your finger-tips (40:1 range available).
A. C. POWER INPUT
The speed you need, here . . . Once selected, the motor speed remains constant—regardless of load.
D. C. DRIVE MOTOR
Any rating up to 150 H.P.
All types of enclosures.

THE MAGNETIC AMPLIFIER

— HEART OF THE SELECT-A-SPEDE

The Magnetic Amplifier, a self-saturating reactor, like a transformer, contains no moving parts — no parts requiring maintenance or periodic replacement. Its function in the Select-A-Spede, is to constantly regulate the field currents of both motor and generator. It requires no "warm up" period, has an extremely fast response to changing conditions, and is completely reliable at all times.

For economical "on the spot" conversion of AC power for an adjustable speed drive (even better than a DC motor supplied from a constant voltage power supply) — the Louis Allis Select-A-Spede is unsurpassed. It is the only AC adjustable speed drive offering the advantage of the new magnetic amplifier control — with close speed regulation at all rated speeds and loads.

The Select-A-Spede also offers a variety of optional features, such as: reversing, dynamic braking, jogging, sequence control, controlled acceleration, interlocked slow speed start, multi-motor drives, etc. It is possible to provide a Select-A-Spede Drive to exactly suit your special requirements.

For further information, contact your nearest Louis Allis Application Engineer or write for Bulletin 1100-B.

LOUIS ALLIS

THE LOUIS ALLIS CO., MILWAUKEE 7, WIS.

FLEXLOC

SELF-LOCKING NUTS

Help PTC to "KEEP 'EM ROLLING"!

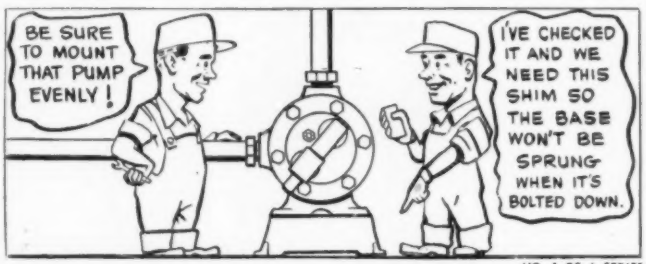
Every day thousands of Philadelphians depend on Philadelphia Transportation Company buses. To "keep 'em rolling," PTC's maintenance must be constant and thorough, since minor failures often cause major breakdowns.

For example, the hex nuts on bus rear axle flanges were being loosened by vibration, despite periodic inspections. Sheared studs resulted. Replacements were expensive, disrupted schedules and loss of riders' goodwill even more so. PTC tried FLEXLOC Self-Locking Nuts, found them a simple, economical solution to the problem.

FLEXLOCs stayed *tight*, eliminated shearing of studs. Yet FLEXLOCs were easy to remove when necessary, could be re-used again and again. Furthermore, FLEXLOC *dependability* reduced the number of maintenance checks needed, effecting additional savings.

If you have to contend with vibration in your business, try FLEXLOC Self-Locking Nuts—free! Just tell us the size, and we'll gladly send samples.

SPS STANDARD PRESSED STEEL CO.
JENKINTOWN 20, PENNSYLVANIA



NO. 1 OF A SERIES

How To Get The Most Work Out Of Your VIKING PUMPS

When mounting a Viking Rotary Pump and bolting it down, be sure that the base is not sprung. Bolting the pump down over an uneven surface may cause binding and heating in the stuffing box. It may cause working parts of the pump to bind and wear beyond repair in a short time. The pump must be free enough to turn the shaft by hand.

Get EXTRA wear out of your Viking Pumps by giving them EXTRA care. The Viking Service Manual tells you how. It's a handy, illustrated booklet giving you practical help in mounting, operating and maintaining Viking Pumps. Write for your copy of Manual X today. It's FREE.

See Our Catalog In SWEETS

Viking PUMP COMPANY
Cedar Falls, Iowa

ENGINEERS DESIGNERS PHYSICISTS

The Aerophysics & Atomic Energy Research Division of North American Aviation, Inc. offers unparalleled opportunities in Research, Development, Design and Test work in the fields of Long Range Guided Missiles, Automatic Flight and Fire Control Equipment and Atomic Energy. Well-qualified engineers, designers and physicists urgently needed for all phases of work in

Supersonic Aerodynamics
Preliminary Design & Analysis
Electronics
Electro-Mechanical Devices
Instrumentation
Flight Test
Navigation Equipment
Controls
Servos
Rocket Motors
Propulsion Systems
Thermodynamics
Airframe Design
Stress & Structures

●

Salaries Commensurate with training and experience

Excellent working conditions. Finest facilities and equipment

Outstanding opportunities for advancement.

Write now—Give complete resume of education, background and experience

●

Personnel Dept.
Aerophysics & Atomic Energy Research Division

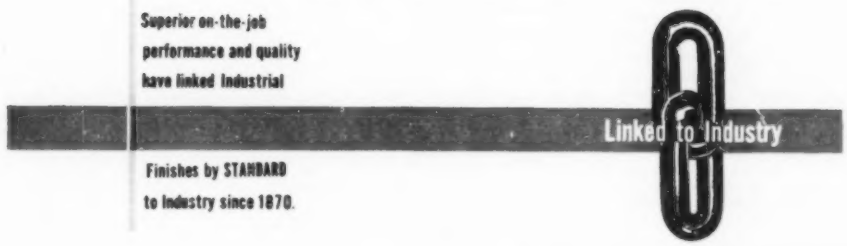
North American Aviation
INC.
12214 LAKEWOOD BLVD.
DOWNEY, CALIFORNIA

Simuplate FOR GOLD, BRASS AND BRONZE COATINGS

With shortages and restrictions on metals, you can keep your production line moving with SIMUPLATE—a practical new organic coating. When applied over properly prepared surfaces it develops the bright lustre of either polished gold, brass or bronze. It's passed many exhaustive tests for wearability under all types of conditions.

Let us tell you more about SIMUPLATE and show you how easily you can get striking effects with combinations of SIMUPLATE finishes. Write or call today.

Superior on-the-job performance and quality have linked Industrial



Finishes by STANDARD to Industry since 1870.

Finishes to meet U. S. Government specifications.

STANDARD VARNISH WORKS

Makers of Fine Finishes Since 1870

NEW YORK
2600 Richmond Terrace
Staten Island 3, N. Y.

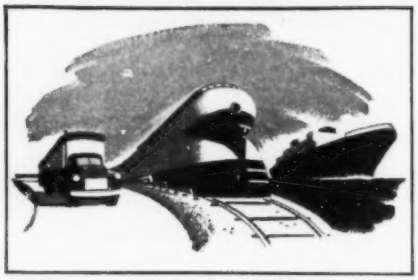
CHICAGO
2600 Federal Street
Chicago 16, Ill.

Bendix-Skinner

ORIGINATOR OF **MICRONIC** FILTRATION

the *Finest*

Answer to Any Filtering Problem



For over twenty years ***Bendix-Skinner*** has specialized in solving the filtering problems that "couldn't be done." From this experience has come entirely new and exclusive filtering techniques which do even the work-a-day filtering jobs better and at lower long-range cost. Tell us about your problem—nine times out of ten ***Bendix-Skinner*** filters will supply the "finest" answer.

***Over 350 Models** providing filtration from ½ micron (.000019") upwards at flow rates from 1 to 5000 g.p.m.*

SKINNER PURIFIERS DIVISION OF
1503 TROMBLY AVENUE
DETROIT 11, MICHIGAN
Bendix AVIATION CORPORATION
Export Sales: Bendix International Division, 72 Fifth Ave., N. Y. 11, N. Y.

Look at the features of these unique standardized right-angle bevel gear drives:

- Capacity of equipment many times their size and weight
- Suitable for manual or power-operated systems
- High load capacity, long service life, and neat appearance in a compact design.
- Two basic models meet requirements of almost all applications
- Ratio 1:1 in 1/3 hp and 1 hp at 1,800 rpm with ultimate static torque of 250 and 750 in. lbs. respectively

CHECK THESE FEATURES . . .	
√	Hardened gears
√	Antifriction bearings
√	Flanged end mountings
√	Three-bolt side mounting
√	Internal pilot on mounting ends
√	Lubricated for life

SOLD THROUGH LEADING DISTRIBUTORS THE COUNTRY OVER

AIRBORNE
ACCESSORIES CORPORATION

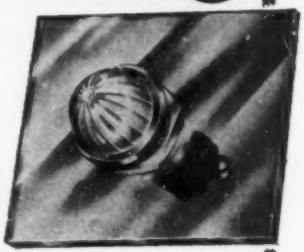
Note our new address ➧ 1414 Chestnut Avenue
Hillside 5, New Jersey

© A.A.C.

FOR YOUR PANEL DIALCO

A NOVEL and UNIQUE CIRCUIT INDICATOR

DESIGNED FOR
NE-51 NEO" AMP
For 110 or 220
volt circuits
The required resistor
is an integral part
of this assembly
—"built-in."
RUGGED
DEPENDABLE
LOW IN COST



PATENTED: No. 2,421,321; Cat. No. 521308-997

WILL *YOU* TRY A SAMPLE?

Write on your company letterhead. We will act at once. *No charge, of course.*

SEND FOR THE 192 PAGE HANDBOOK OF PILOT LIGHTS

Among our thousands of Pilot Light Assemblies there is one which will fit your special conditions. Many are especially made and approved for military use. We pride ourselves on prompt deliveries—any quantity.

ASK FOR OUR APPLICATION ENGINEERING SERVICE

Foremost Manufacturer of Pilot Lights

The DIAL LIGHT COMPANY of AMERICA

900 BROADWAY, NEW YORK 3, N. Y. SPRING 7-1300

THIS NEW MATERIAL

MAKES THESE PARTS AND SAVES YOU $$$$

A rotor with three precious metal caps to act as contacts was needed by a leading automotive manufacturer for use in a special switch. Soldered-on caps were soft and expensive. Rivets might work loose.

As an ideal solution, this new Makepeace insert material was created. It consists of precious metal slugs brazed into strip stock and positioned to form the desired part. The precious contact material is *only* where it is wanted, firm and secure for blanking and forming. And . . . of great importance . . . it is hard and wear-resistant due to cold working.

This new material is particularly adapted to rotors in switches and small bridge contacts . . . *any* formed part embodying two or more contact points. *Please note* . . . Patents have been applied for.

For better performance and lower unit cost, design your next switch to make use of this new material. Our own staff of thoroughly experienced engineers and metallurgists are at your service to assist in working out your particular problem.

Your inquiries are cordially invited and will receive our prompt and interested attention.

D. E. MAKEPEACE COMPANY

Laminated and Solid Precious Metals for Industrial Use • Fabricated Parts and Assemblies • Bar Contact Material • Precious Metal Solders

MAIN OFFICE AND PLANT, ATTLEBORO, MASSACHUSETTS
NEW YORK OFFICE, 30 CHURCH STREET
CHICAGO OFFICE, 30 EAST WASHINGTON STREET

Thousands or Millions....

ALUMICAST can produce quality castings in quantity, exactly to your specifications

Let ALUMICAST give you a helping hand with your casting problems. You'll be agreeably surprised with the results if you ask our nationally recognized authorities in research, metallurgy, engineering and production to put their know-how to work for you.

Here at ALUMICAST, we have the most modern laboratory and production equipment to make permanent mold and die castings in aluminum or magnesium. Every step, from ingot to casting, is rigidly regulated. The quality of ALUMICAST castings is outstanding because of expert scientific control. This value, we call "E.S.C.", is of great importance to you. It helps make good products better.

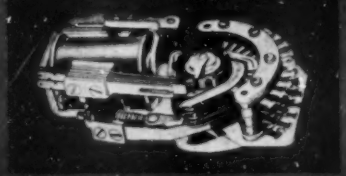
No matter where you are located, you are cordially invited to consult us about your casting requirements for civilian or defense needs. We have sales engineers and representatives in leading cities. If you do not know the name of our man nearest you, write direct to us. ALUMICAST CORPORATION, 1517 N. Kilpatrick Avenue, Chicago 51, Illinois.

ALUMICAST

ALUMINUM and MAGNESIUM PERMANENT MOLD and DIE CASTINGS

"E.S.C." EXPERT SCIENTIFIC CONTROL

when you specify stepping switches

	type 44	type 45
large bank capacity	Up to six 10-point bank levels. Levels can be used independently for 10-point operation...in pairs for 20-point operation...in groups of three for 30-point operation.	From 2 to 10, or more, 25-point bank levels. Levels can be used independently for 25-point operation...or in pairs for 50-point operation.
positive operation	Coil-spring driven; steps when the coil is de-energized. Operation can be either impulse-controlled or self-interrupted.	Coil-spring driven; steps when the coil is de-energized. Operation can be either impulse-controlled or self-interrupted.
high speed	A typical three-level 10-point switch operating on 48 volts d-c runs approximately 80 steps per second, self-interrupted...35 steps per second, impulse-controlled.	A typical ten-level 25-point switch operating on 48 volts d-c or 115 volts a-c runs approximately 75 steps per second, self-interrupted...35 steps per second, impulse-controlled.
variety of coils	For any d-c voltage up to 110. Regularly provided for operation on 6, 12, 24, 48, 60 or 110 volts d-c.	For any d-c voltage up to 110, or for 115 volts a-c. Regularly provided for operation on 6, 12, 24, 48, 60 or 110 volts d-c.
		

find them in Automatic Electric

telephone type stepping switches

positive stepping
Wipers locked at each step without pawl stop blocks; this simplifies adjustment, eliminates maintenance.

"double twin" wipers
Bifurcated tips touch *both* sides of bank contact...give twice the dependability of twin contacts.

operates at −72°C
Both switches tested to operate efficiently at −72° C...especially important in military applications.

You can meet a wide range of requirements with the unusual flexibility of these two stepping switches. In many applications they can replace 10, 20, or more relays with resultant savings in space and weight. The Type 44 is miniature in size (max. 2" x 2⅜" base mount) and weight (avg. 14 oz.). Yet it offers capacity, speed, and smooth-running dependability for your most complicated space and weight applications. The Type 45, the only switch of its kind for both d-c and a-c application, offers even greater capacity and adaptability to the exact number and arrangement of bank levels you need. Write for complete data in Circular 1698-A. Address:

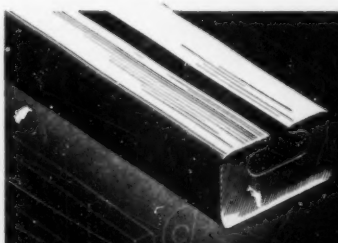
AUTOMATIC ELECTRIC SALES CORPORATION
1033 West Van Buren St., Chicago 7, Ill.
Offices in principal cities

RELAYS SWITCHES
PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF
AUTOMATIC ELECTRIC
CHICAGO

on land, sea and in the air

Acadia Synthetic Rubber Products are once again in great demand for the nation's defense. They are serving in a large variety of important purposes in weapons and equipment on land, sea and in the air. Manufacturers in hundreds of industries have learned they can always depend upon the uniformly high quality of Acadia Synthetic Rubbers.

They are readily compounded to exact degrees of elasticity, resilience, plasticity: offer high resistance to oil, age, light, temperature extremes. They can be molded or extruded—cut to close tolerances in endless shapes and sizes.



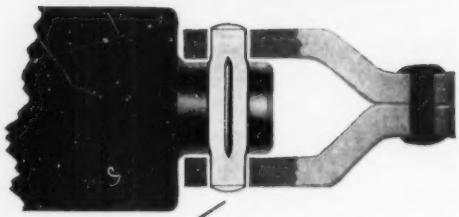
sheets • tubing • strips
• channel • washers •
seals • bellows •
gaskets • rings •
extrusions • cut parts

ACADIA *Synthetic* PRODUCTS

Processors of Synthetic Rubber and Plastics • Sheets • Extrusions • Molded Parts

DIVISION WESTERN FELT WORKS
4033-4117 Ogden Avenue, Chicago 23, Illinois

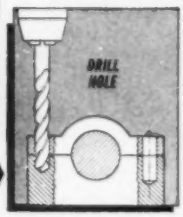
FASTER...EASIER
Assembly with
DRIV-LOK PINS



TYPE "E" PIN

- ★ Simple Installation
- ★ Low Cost
- ★ Wide Selection of Materials
- ★ Versatile...Types for Most Applications
- ★ Vibration and Shock-proof

2 EASY STEPS

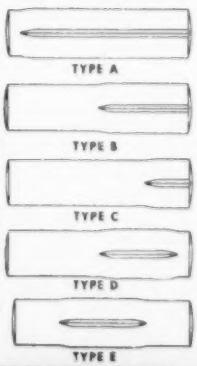


DRIV-LOK Pins speed assembly because they require only a drilled hole for installation—no taper or size reaming necessary. Drill the hole—drive or press in the pin . . . the job is complete.

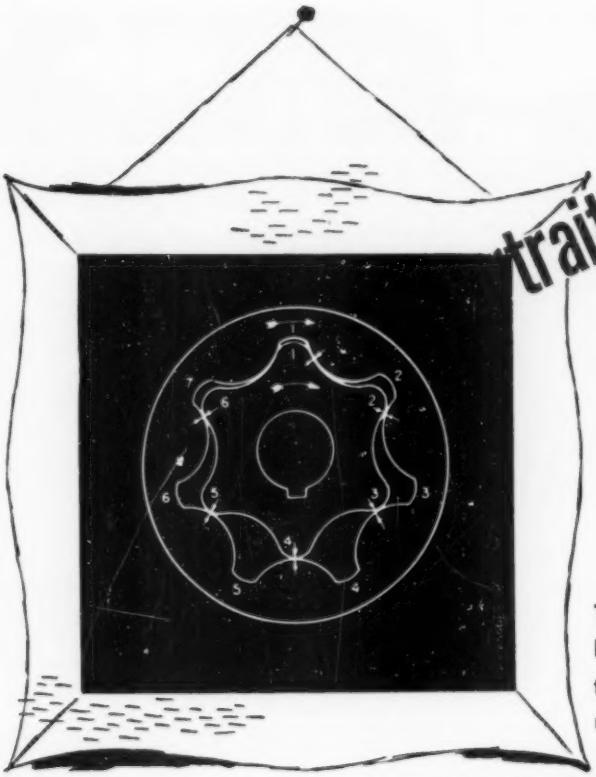
Type E DRIV-LOK Pins (illustration at top) find many applications as pivot pins, T-Handles in tools and valves, cotter pins, cross pins, etc.

DRIV-LOK Pins are available in many types—in carbon steel, stainless, alloy and brass; diameters from 3/64" to 1/2", can be heat treated or plated to your specifications.

Write for catalog and samples, giving nature of your fastener problem.

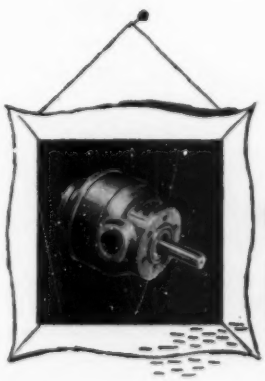


DRIV-LOK PIN COMPANY
723 Chauncey St. • Sycamore, Ill.



trait of efficiency

The unique device whose likeness you see here—the famed Gerotor gear mechanism—is the No. 1 reason for the high volumetric and mechanical efficiency of Gerotor Hydraulic Pumps. Revolving in the same direction at low relative speed, the two Gerotors wear less—last longer—assure more uniform flow. Pressures to 1200 p.s.i. continuous, 1500 intermittent. GEROTOR MAY CORP., Baltimore 3, Md.



GEROTOR hydraulic pumps

WRITE US ABOUT

Boltaron

BOLTARON carrying case for Cellux flash unit, fabricated by Gregstrom Corp., Cambridge, Mass.

The tough, new, eye-appealing, low-pressure forming material that molds easily, inexpensively!

Now BOLTARON is available in quantity . . . the amazing, light, new material that can be shaped in aluminum, sheet metal, composition, and even wood molds by all standard forming methods.

BOLTARON FEATURES: resists impact, abrasion, alkalis, acids, staining; is waterproof, mildew-proof, vermin-proof, grease-proof. It can be punched, drilled, tapped, bolted, riveted, sawed, sheared, cemented, sewed, sanded, printed, Hot-Stamped, cleaned, waxed. Available in a range of decorative colors, finishes and grains.

Partial list of BOLTARON USES

- Typewriter Cases
- Machine Housings
- Fender Guards
- Tote Boxes (especially for food and chemical industry)
- Luggage Cases
- TV Masks
- Toys
- Ice Cream and Deep Freeze Lids
- Trays (home and compartment style)
- Refrigerator and Deep Freeze Door Liner
- Auto Door Panels
- Dash Panels
- Sun Visors

For booklet with specifications, fabricating techniques and suggested uses, write Dept. EB-9.

Boltaron

BOLTA PRODUCTS SALES, INC., Lawrence, Mass.

For help in designing and making special injection or compression molded items, write our Custom Molding Division.

FABRICATED WIRE CLOTH AND PERFORATED METAL

Screens -- Strainers -- Filters

Buy from a plant that's equipped to do your fabricating job—quickly, easily—all under one roof. Highly trained personnel, modern equipment, large material stocks, enable Pittsfield to speedily fill your needs economically and to high standards of performance.

FABRICATION SERVICES

- Shearing
- Soldering
- Brazing
- Welding
- Crimping
- Plating
- Stamping

SPEEDY QUOTES AT NO OBLIGATION

PITTSFIELD PRODUCTS, Inc.
ANN ARBOR, MICHIGAN

WILLIAMS

DROP-FORGINGS

ANY SHAPE · ANY MATERIAL · COMPLETE FACILITIES

Write for Free Forging Data Folder . . . Helpful, Informative

J. H. WILLIAMS & CO., "The Drop-Forging People" BUFFALO 7, N. Y.

FOUR TYPES OF···

WOVEN BRAKE LINING

COVERING ALL INDUSTRIAL REQUIREMENTS FOR INTERNAL AND EXTERNAL BRAKES

sizes 1 1/2 x 5/32" through 4 x 3/8"

LARGE CAPACITY (10,000 ft. per Day)

LONG EXPERIENCE (since 1927)

SPECIALISTS IN SHORT RUN ORDERS

WE INVITE YOUR INQUIRIES

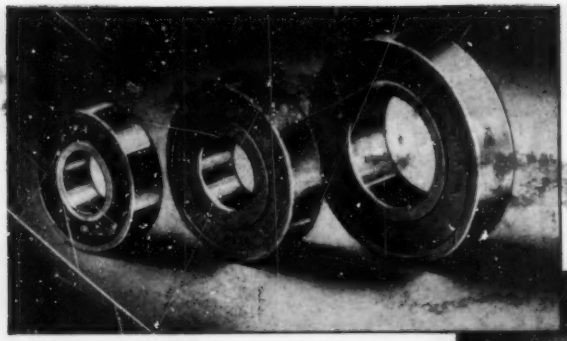
SOUTHERN FRICTION MATERIALS CO.
CHARLOTTE, N. C., U. S. A.

A special welcome for SMALL ORDERS for SPRINGS

Need experimental springs . . .
or a special small lot . . . or emergency replacements?
Raymond's Small Order Department operates
on its own, with production facilities, cost records and
delivery schedules scaled to this class
of work alone. It pays big dividends to
bring your small spring orders to
Raymond, for the right start
toward better spring performance.

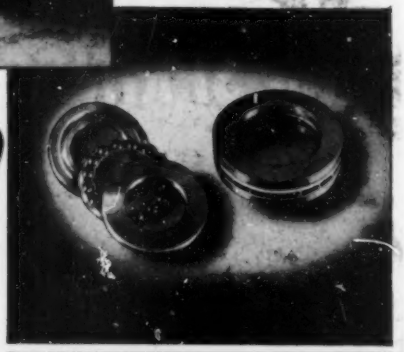
Raymond Springs

Raymond Manufacturing Co.
DIVISION OF ASSOCIATED SPRING CORPORATION
Corry, Pennsylvania



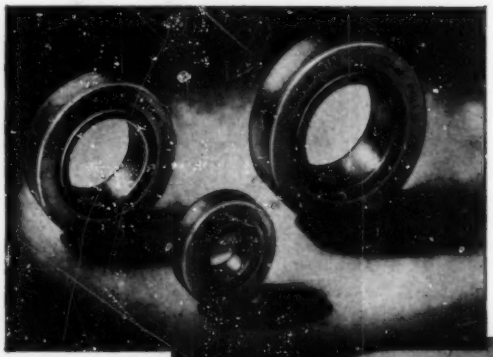
Series 1600 "ground" precision radial bearings.

Series 1000 "ground" precision thrust bearings.



WHAT PRICE *Quality?*

NICE BALL BEARINGS



Series 400 low cost "unground" radial bearings.

Series 600 low cost "unground" thrust bearings.

"Low cost" bearings can be "high quality" bearings. Quality is relative — a comparative measure of dollar value, and can be built into the most inexpensive product.

The Nice Line ranges from close tolerance, precision "ground" ball bearings to low cost "unground" ball bearings of inexpensive design and construction. For "top quality" at any price, specify Nice.

NICE

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA

Now YALE CAM LOCKS

FOR YOUR METAL CABINETS

CAPPED WITH STAINLESS STEEL

It's the same fine lock with the same fine quality name plus a new permanent surface!

• It's better! *But no more expensive*—better looking, better engineered. It licks the problem of plating on die-casting through the use of a stainless steel scalp.

This new idea—in the Yale line of cam locks gives you another good reason for specifying Yale for every metal cabinet job. For here is a long-lasting beauty treatment that will add to the attractiveness of your cabinet and, of course, give you Yale lock security. For detailed information write The Yale & Towne Manufacturing Co., Dept. S-329, Stamford, Conn.

YALE & TOWNE

YALE is a registered trade mark.

RUBATEX GASKETS

prevent cold loss around freezer box doors

Excellent insulation
Resilient at low temperatures
Zero moisture absorption

A combination of ideal characteristics makes RUBATEX Closed-Cell Rubber the most efficient material for gasketing refrigerator and cold storage room doors.

The dense closed cell structure of RUBATEX is permanently resilient and is unaffected by low temperatures. RUBATEX provides a tight seal, even over irregular surfaces, with a minimum of pressure. It has high insulating properties and cannot absorb moisture.

Try RUBATEX for your gasketing, cushioning, or vibration damping application. It is made in soft, medium and firm forms and in natural rubber and synthetic stocks. Engineering advice and assistance is available. For further information write for Catalog RBS-12-49. Great American Industries, Inc., RUBATEX DIVISION, BEDFORD, VA.

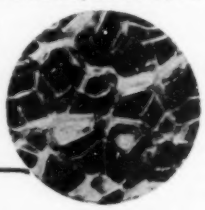


Photo-micrograph shows how each cell of RUBATEX is completely sealed by a wall of rubber. The material cannot absorb moisture. It has high insulating values, resists oxidation and is rot and vermin proof.

RUBATEX® CLOSED CELL RUBBER

ENGINEERING ADMINISTRATIVE POSITION

One of the largest airframe manufacturers has an opening for an exceptionally well qualified engineer with an extensive aircraft structural background and experience in structural research. Engineers with advanced degrees will be given preference, but those with B.S. degrees will be considered.

Responsibilities include the administration of highly scientific research projects in all fields of airframe and missile structural analysis and design.

Applicants should submit summary of education and experience to:

P-1728, Product Engineering
68 Post Street, San Francisco 4, Calif.

(Our employees know about this ad)

HERE'S HELP

for technical and business men

NEW 1951 Catalogue of McGRAW-HILL BOOKS

DESCRIBES OVER 2,000 BOOKS

Here is a guide to practical, expert information on many business and technical subjects. This catalogue contains clear, concise descriptions of more than 2,000 books written by leaders of business, industry and research. Get your copy now. In it you will find an up-to-date listing of books that give you the facts—experience—data—you need in solving your particular problems.

McGraw-Hill books bring you the experience of experts in your field

MAIL THIS COUPON FOR YOUR FREE COPY

Readers Service Department
McGraw-Hill Book Co., Inc.
330 W. 42nd St., N. Y.

Send me a free copy of the New 1951 Catalogue of McGraw-Hill Books. I want to know more about: (Name subjects of most interest to you.)

.....

.....

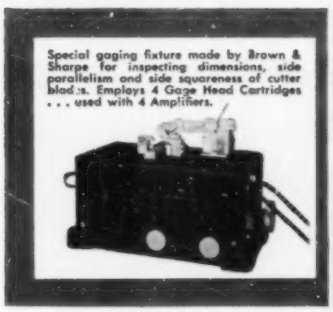
Name .....

Address .....

City .....State.....PTB-9-51

Adaptable Foundation for Countless Precision Gaging Set-Ups

TYPICAL APPLICATIONS


Special gaging fixture made by Brown & Sharpe for inspecting dimensions, side parallelism and side squareness of cutter blades. Employs 4 Gage Head Cartridges . . . used with 4 Amplifiers.

Special gaging fixture, custom-made by Brown & Sharpe, permits gaging of meter valve plate flatness to .00001", when used with Brown & Sharpe Amplifier.

Custom-made fixture, employing Brown & Sharpe Gage Head Cartridge and one Amplifier, measures major and minor I.D.'s of tapered bores; indicates internal angle accuracy.

Brown & Sharpe Gage Head Cartridge and Electronic Amplifier

Here's a really practical basis for versatile precision gaging equipment at reasonable cost.

The Brown & Sharpe Gage Head Cartridge and Electronic Amplifier provide accurate gaging, with direct-reading indications, in units of .0001" to .00001". Simple jigs or fixtures to hold the cartridge for many special gaging jobs can easily be built in your own plant. By shifting the same cartridge among a number of fixtures, you can do precision gaging of practically any length, diameter, or other dimension — with minimum investment in equipment.

Both the Gage Head Cartridge and the Electronic Amplifier are built for severe service conditions. The dustproof, moisture-proof cartridge can be safely exposed to abrasives or coolant. Write for complete literature on this multi-use precision gaging equipment. Brown & Sharpe Mfg. Co., Providence 1, R. I., U.S.A.

WE URGE BUYING THROUGH THE DISTRIBUTOR

B·S

Brown & Sharpe

Designing for Compactness?

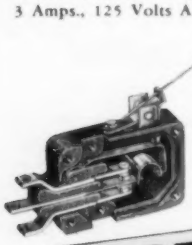
TRY THIS PENCIL-SLIM SNAP ACTION SWITCH for Size!

ACRO MODEL M...A Giant in Performance—A Pigmy in Size

This *little* Acro snap action precision switch has been the answer to many a designer's space problem. Though overall not much bigger than a postage stamp it carries a Und. Labs. Inspd. rating of 10 Amps., 125 Volts A. C.; circuit, S. P. D. T., normally open or normally closed.

MODEL M "COIN" SWITCH

This same basic switch is capable of being operated by very light actuating pressures—as low as 2½ grams, making it especially suited to coin operated devices. The coin model is rated at 3 Amps., 125 Volts A. C.



INTERIOR VIEW, COIN MODEL WITH WIRE LEAF ACTUATOR

Showing Acro's exclusive rolling spring operating principle that is the key to longer life and more positive operation. The millions of Acro switches in use on countless products conclusively demonstrate the superiority of this design in service.

ACRO SNAP ACTION ROLLING SPRING SWITCHES

ACRO MANUFACTURING CO.
Columbus 16, Ohio

HERE'S THE STRONGEST BRONZE

HY-TEN-SL
A Bronze as Strong as Nickel Steel

TRADE-MARK

Grade of HY-TEN-SL	1AA	1A	1	2	3	4
TENSION						
Ultimate tensile strength lbs. per sq. in.			(Minimums)			
Sand Cast	125,000	115,000	100,000	100,000	90,000	85,000
Rolled 1" and under	.....	120,000	110,000	105,000	95,000	85,000
Rolled or Forged, over 1"	.....	115,000	100,000	100,000	90,000	85,000
Yield Point (divide: method)						
Sand Cast	95,000	75,000	60,000	55,000	45,000	40,000
Rolled 1" and under	.....	75,000	65,000	60,000	50,000	45,000
Rolled or Forged, over 1"	.....	75,000	65,000	60,000	50,000	45,000
Elongation in 2"—%						
Sand Cast	10	12	14	15	20	25
Forged or Rolled	.....	12	13		15	20
Reduction in area—%						
Sand Cast	.....	12	14	15	20	25
Forged or Rolled	.....	12	13		15	20
COMPRESSION						
Yield Point—						
lbs. per sq. in.	70,000	65,000	50,000	50,000	40,000	35,000
Permanent Set at						
100,000 lbs. per sq. in. (max.)	.015	.020	.030	.050	.080	.125
Brinell hardness, No.	250	240	220	200	175	150

List of U. S. Government Specifications Covering HY-TEN-SL Bronze

ARMY
Forgings, Rolled Rod QQ-B-721 Class B
Castings...QQ-B-726 Class B and C

NAVY
Forgings and Rolled Rod 46B15d Class B
Castings, Aluminum-manganese Bronze 46B19

WATERTOWN ARSENALS and OTHER ARMY
Castings WXS-5
Forgings and Rolled Rod.....WXS-2

NAVAL GUN FACTORY
Washington Navy Yard
Castings—Trunnion Metal.....O.S.350

AIRCRAFT
See Navy and Army (above).

Send for 46 Page "Text Book"

AMERICAN MANGANESE BRONZE COMPANY

4705 RHAWN ST., PHILADELPHIA 34, PA.
Pittsburgh, Pa.

Established 1909

FOR FINER APPEARANCE, PERMANENT READABILITY

Identify your products with metal name plates by

CHICAGO THRIFT-ETCHING CORPORATION

We'll gladly quote, without obligation to you, on your requirements for name plates, instruction plates, dials, panels, scales, etc. We are equipped also to apply special finishes to aluminum products and parts, including ANODIZING by the exclusive Alumilite process. Write today for detailed information and quotations.

CHICAGO THRIFT-ETCHING CORPORATION
1555 North Sheffield Avenue, Chicago 22, Ill., Dept. B
SUBSIDIARY OF DODGE MFG. CORPORATION, MISHAWAKA, IND.

Now Ready

a new, revised edition
of this popular P-K
ASSEMBLY
HANDBOOK

Here are the essentials of P-K Self-tapping Screw selection and use, condensed into a 24-page, pocket-size reference booklet. This new edition is redesigned and improved to give you all the information you need, and help you find it faster.

It's ready just in time to help you with your current task of training a large number of new assembly workers. And for veterans, too, it will help avoid mistakes that cause spoilage and slow up production.

Get the copies you need from your P-K Distributor—ask for Form No. 480. Or write Parker-Kalon Corp., 200 Varick St., New York 14.

Tells WHERE to use WHAT P-K Self-tapping Screw in Metals or Plastic

Gives Hole Sizes and Application Data for all types of P-K Screws

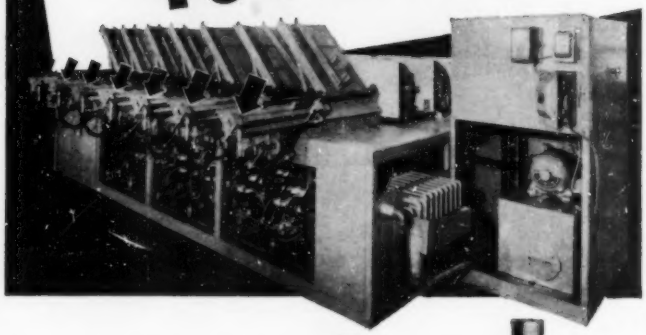
IF IT'S P-K IT'S O.K.

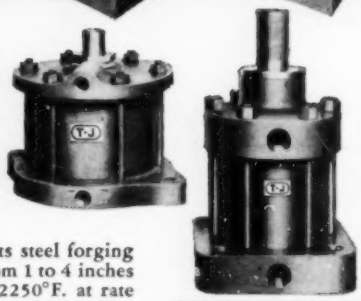
The Original
PARKER-KALON® SELF-TAPPING SCREWS

A TYPE AND SIZE FOR EVERY METAL AND PLASTIC ASSEMBLY

Job File No. 3259

Feeds Automatically WITH T-J CYLINDERS



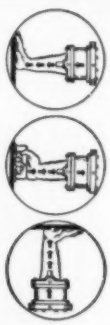


T-J Hydraulic Cylinders furnish efficient, automatic "push power" for feeding devices in this new Ajax-Northrup induction forge heating equipment.

This unit—manufactured by Ajax Electrothermic Corp., Trenton, N. J.—automatically heats steel forging stock in sizes ranging from 1 to 4 inches (rounds or squares) at 2250°F. at rate of 7500 to 8500 lbs. per hour. Has space for 8 heating stations . . . each with *hydraulically operated billet feeding devices employing T-J Cylinders.* These cylinders also eject heated bars automatically. Induction heating with this equipment results in uniformity of successive billets fed to the forge—thus controlling quality of finished forgings and reducing rejects.

Do you have a tough job in power movement—pushing, pulling or lifting? Let T-J help you *simplify machines, save labor* and *cut costs* by using T-J Air or Hydraulic Cylinders! Many standard sizes and styles . . . cushioned or non-cushioned . . . 100 lb. or 50,000 lb. Precision-built, long life. Write for more information. The Tomkins-Johnson Co., Jackson, Mich.

FOR POWER MOVEMENT IN ANY DIRECTION



100 LBS. or 50,000 LBS.

35 YEARS EXPERIENCE

TOMKINS-JOHNSON

VALVES • AIR AND HYDRAULIC CYLINDERS • CUTTERS • CLINCHERS

T-J

McGRAW-HILL

TECHNICAL WRITING SERVICE

Writing

Whether you need an instruction book or service manual to accompany your equipment written to government specifications . . . or product catalogs . . . or training booklets . . . or industrial literature . . . our writing staff can do the job for you. It will do the research, planning, writing, and organizing to satisfy your requirements.

Illustrating

For government publications or industrial literature, our Art department can meet your specifications, or those of the government agency, for isometrics, exploded views, cutaway views, retouched halftone copy, rendering, lettering, or any other type of art work. It can design to standardized format or present industrial visuals of compelling appeal.

Editing

The editors of our staff are thoroughly familiar with government publication specifications. In addition to being technical editors, they are also experienced in rewriting and organizing rough manuscript, or in revising published material. Many have taught or have been trained in teaching and are, therefore, able to recommend or inject proper pedagogical presentation of material.

Printing

Our printing, binding, and paper resources are among the best in the country. Every type of reproduction is available . . . offset, letterpress, multigraph, or even mimeograph. We can handle a complete printing job or, in the case of offset, furnish repro copy when other facilities must be used.

Save money and time . . . let our staff be your staff for technical publications. Write for our brochure or ask our representative to call.

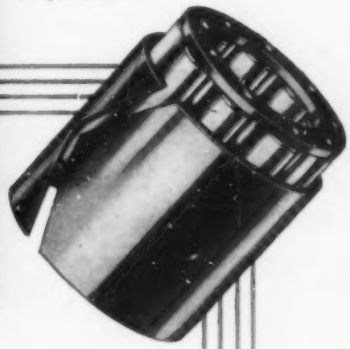
Technical Writing Service

McGRAW-HILL BOOK CO., INC.

330 West 42 Street
New York 18, N. Y.

Save 3 ways With These ROLLWAY Steel Cage BEARINGS

Type A — Roller assembly with split sleeve.



SAVE ON INITIAL COSTS

Skillfully engineered for the usual commercial applications, and produced at a price well within competitive range.

SAVE ON ASSEMBLY COSTS

You'll save time and labor through easy installation—just press sleeve in housing at unit-assembly bench, then slide the rollers on the shaft at group-assembly station.

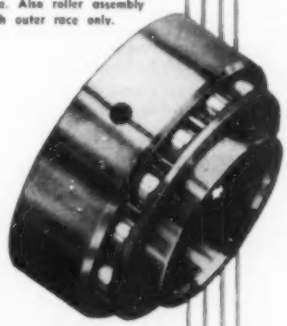
SAVE ON MAINTENANCE COSTS

Run longer and with better efficiency under heavy loads, continuous operations and varying speed conditions. Promotes easier starting, running—minimizes replacements.

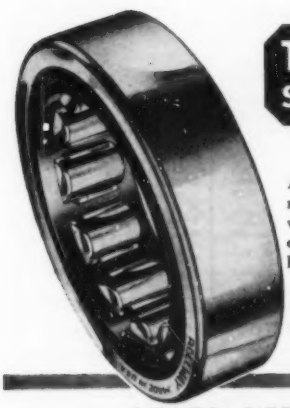
***FREE* ENGINEERING SERVICE**

Send your design problems to us—our engineers will gladly recommend the right bearing for your needs. No obligation. Write today!

Type D — Roller assembly with solid inner and outer race. Also roller assembly with outer race only.



TRU-ROL ROLLWAY'S Steel-Retainer Bearings



An economical steel-retainer bearing, the TRU-ROL maintains throughout its long life, the tru-rolling which approximates the precision of ROLLWAY'S more expensive bronze-retainer type bearings. The Guide Lip Does It!

Type B Tru-Rol (Illus.) without inner race. Type BE, with inner race.

SALES OFFICES

Syracuse	Detroit	Philadelphia
Chicago	Boston	Pittsburgh
Houston	Cleveland	Los Angeles

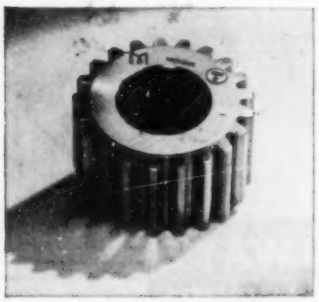
ROLLWAY
BEARING COMPANY, INC.
SYRACUSE 4, N. Y.

We're up to our *Ears*

...and we like it —and we know what caused it.

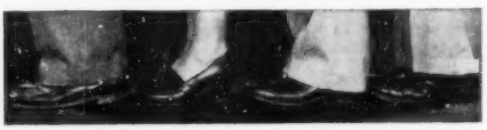
At IGW, your precision gear problem is engineered and scheduled efficiently —then produced on modern equipment operated by skilled craftsmen— and controlled by rigid inspection.

Result . . .
. . . you like it—and you know what caused it.



This planet pinion has .0003 MICROWN* —IGW's new after-grinding, high precision crowning process.

*PATENT PENDING



Indiana GEARS

GEARS • CAMS • INTRICATE AND PRECISE MACHINE PARTS

INDIANA GEAR WORKS • INDIANAPOLIS 7, IND.

An outstanding reference on all phases of planning, control, design, tooling and operations in the mechanical manufacturing industries.

THIS Handbook brings you the most modern, authoritative data on the design, fabrication, maintenance and economical use of tools and machinery used in industry. Of importance to anyone connected with mechanical processing of finished products, it covers product design and cost estimating, the economical selection of machines, processes and tools, the analysis and improvement of set-ups and operations. Consult it for rules, formulas, procedures and useful data. Use it with complete confidence; data are based, wherever possible and practicable, on standards established by the government, the professional associations, and leading industrial companies throughout the country.

TOOL ENGINEERS HANDBOOK

American Society of Tool Engineers

Frank W. Wilson, Editor-in-Chief

Written by 144 authorities in the field, this massive reference has been checked and double-checked to insure accuracy from cover to cover. Here are the complete authoritative answers to problems you meet from day to day—brought to you in compact, easy-to-find form.

More than 2000 pages! Over 1500 illustrations! Hundreds of tables, charts, keyed diagrams, symbols, definitions, equations, etc.

A small selection of highlights selected at random to illustrate the scope of this Handbook:

—Describes types of machines, cutting tools, toolholders, fixtures and operations in precision production boring.
—Includes all new techniques and processes of recognized acceptance including Powder Metallurgy, Investment Casting, Plastic Joining of Materials, etc.
—Conventional tables of feeds, speeds and cuts modernized to bring them into line with latest cutting-tool materials and cutting practices.
—Treats, process-wise, such topics as Plaster Mold Casting, Superfinishing, Rotary Swaging, Sheet and strip cold roll forming, Die Hobbing, etc.
—Covers every phase of metal cutting and machinability.
—Discusses welding, gluing and mechanical joining of materials.

Partial Listing of the Handbook's 115 Big Sections which Cover Tool Engineering from A to Z:

- Job Planning and Control
- Small Tools Planning and Control
- General Structure and Properties of Metals
- Properties and Workability of Plastics
- Plastics Forming
- Inspection Equipment and Methods
- Investment Casting
- Milling
- Shrinkage Fits
- Broaching
- Engine Lathes
- Power Bandsawing
- Gear Shaping
- Jigs and Fixtures
- Thread Chasing
- Pressworking of Metal
- Allowances and Tolerances for Cylindrical Fits
- Static and Dynamic Balancing
- Shot Peening
- Punches and Dies
- Drilling, Reaming and Counterboring
- Mechanics, Physics and Mathematics

Mail Coupon for 10-Day FREE Examination

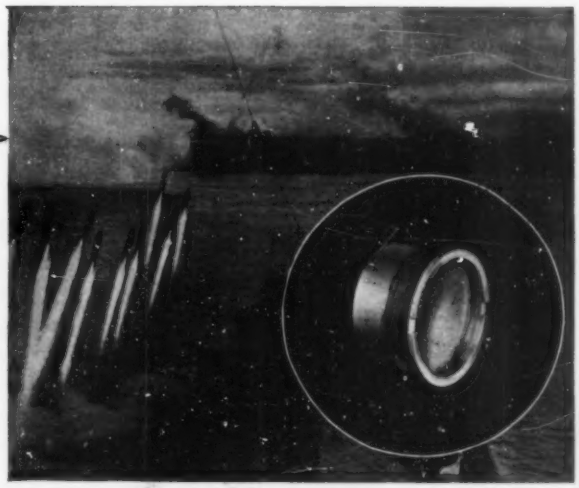
McGraw-Hill Book Co., 330 W. 42nd St., N. Y. 18, N. Y.
Send me the A. S. T. E.'s TOOL ENGINEERS HANDBOOK for 10 days examination on approval. If the book proves satisfactory, I will remit $8.00 in 10 days, and $3.00 monthly until $15.00 is paid. Otherwise, I will return the book postpaid after 10 days. (We pay for delivery if you remit first payment with this coupon. Same return privilege.)

Name .....
Address .....
City ..... Zone ..... State .....
Company .....
Position PTE-9-51

This offer applies to U. S. only.

For Defense or Essential Civilian Use—

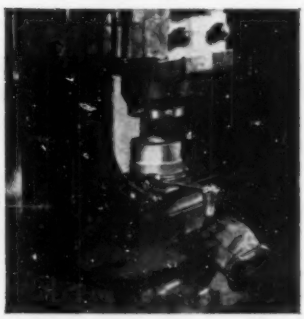
get the most for your Zinc Die Casting Dollar!



This protector cap for Navy rockets is one of many ordnance components now being turned out at high speed by the die casting process. *It is ZINC Die Cast in a single-cavity die at the rate of 180-200 per hour!* Only a few simple secondary operations are required to prepare this casting for its role of protecting rockets during shipment. The cap prevents moisture or dirt from entering the rocket and protects the threads from damage prior to screwing the war head in place at the point where the rocket is loaded.

CAST FAST — AT LOW COST

By using a collet die (which permits the casting of outer surface undercuts, since the cavity parts angularly in opposite directions when the die is opened) the external threads on the protector cap are obtained at high speed *in the casting operation.* Because of the relatively low melting point of the ZINC alloy, the die cost and die upkeep are minimized. Facility in casting, in combination with moderate die costs and an alloy having excellent properties, account for the preference for ZINC Die Castings.



AVOID EXTRA OPERATIONS

Since ZINC Die Castings are produced very close to finished size, the amount of metal to be removed in secondary operations is generally quite small. All that is required to complete the thread protector casting, for example, is the trimming of flash metal in a punch press. The casting is then coated with a protective dichromate film and is ready to have a steel cup press-fitted in its top end. The latter operation is speeded up by the use of permanent magnets in the ram of the press to hold the steel cup in position on the ram while it is driven home.

The same economic considerations apply whether a die casting is designed for civilian or military use. For information on these considerations, ask us—or your die caster—for a copy of "Designing For Die Casting."

The New Jersey Zinc Company
160 Front St., New York 38, N. Y.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

"porous castings"

causing rejects and delivery delays?

WESECO PROCESS

affects quick, invisible seal . . .
insures pressure tightness!

Here's a fast, positive, economical process for insuring against POROSITY in all types of castings—ferrous and non-ferrous! The WESECO process completely penetrates and permanently seals all pores. Castings are processed in a matter of hours, trimming production costs and insuring 100% delivery on schedule!

Outstanding features of Western Sealant:

- Outmodes the use of sodium silicate, varnishes, phenolics and styrenes.
- Invisibly and permanently locks all pores against leakage.
- Applicable to all ferrous and non-ferrous alloys and fibreglass laminates.
- Unaffected by subsequent finishing coats.
- Approved under Army, Navy, Air Force specifications.

WESTERN SEALANT service plants are located in all principal industrial areas in U. S. and Canada. 24-hour customer service. Consult your Classified Telephone Directory or write direct! Free descriptive circular describes complete WESECO Process.

Remember: "If it's not WESECO, it's outmoded!"

Western
SEALANT COMPANY
9042-P Culver Blvd., Culver City, Calif.

MARK-TIME "5400"
BELL TIME SWITCH
is first choice for
ruggedness and
versatility

first where quality counts

MARK-TIME 5400-SERIES BELL TIME SWITCH

U.L. approved for 20 amperes, 125 volt or 10 amperes, 250 volt, 1 HP operation; AC only. Timings available from 60 seconds to 5 hours.

Normally supplied for Center Stud mounting. Other mountings available upon request.

This Mark-Time Two-Purpose unit rings the bell with manufacturers of all types of electrical equipment and appliances.

The "5400" Time Switch turns an electrical device OFF after a pre-set time interval and simultaneously provides a clear warning bell. ON type unit available on special order.

Gives reliable, continuous service under the heaviest duty.

Wide variety of modern dials and knobs.

Write for further information and prices.

MARK-TIME

M. H. RHODES, INC
HARTFORD, CONNECTICUT

In Canada send inquiries to: Ontario Hughes Owens Co. Ottawa, Ontario

EARLE GEARS ARE

PRECISION CUT

When your gears are cut by Earle, close tolerances are strictly maintained, and all machined surfaces are accurately finished. Earle Gear's precision cutting and machining equipment result in smooth, quiet operation—and such is a sign of long life and satisfactory service.

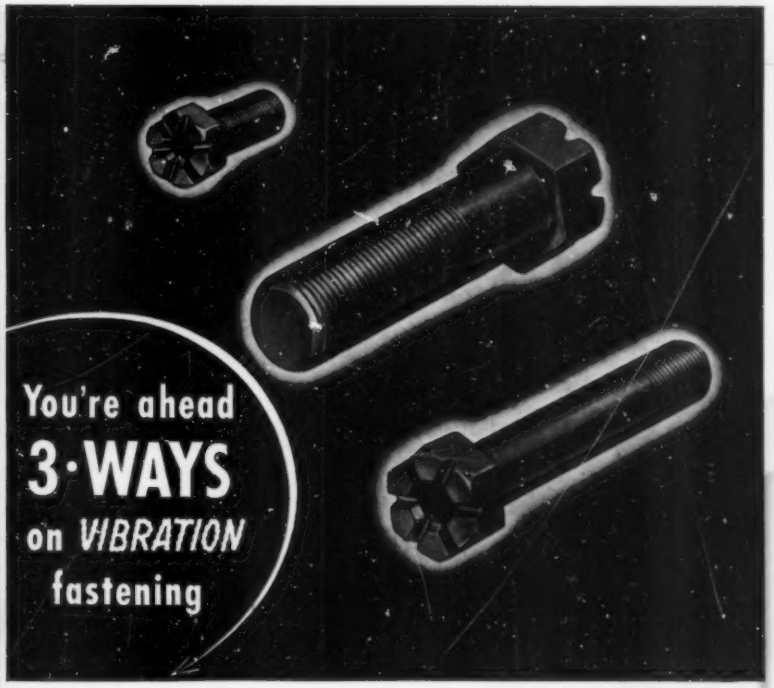
Precision cutting is one phase of Earle Gear's good service. And all Earle Gears of any type made from any practical material in any diameter from inches up to 30 feet—are cut with precision. Send us whatever specifications you may have for quotation.

THE EARLE GEAR & MACHINE CO., 4700 Stenton Ave., Philadelphia 44, Pa. Sales Offices: 149 Broadway, New York 6; 7735 Market St., Youngstown, Ohio

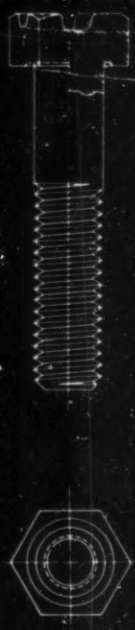
EARLE GEARS

Here's how Slotted-Type Head locks

Flexible diaphragm formed between slotted segments in upper face of bolt head and circular recess adjacent to shank in lower face (section X) acts as controlled spring element when head is properly wrenched against a rigid seat. Diaphragm is reinforced by the continuous-grained segments cold-formed between upset slots in upper face.



You're ahead
3-WAYS
on *VIBRATION*
fastening



with new-type "National" PLACE BOLTS

They're more economical—self-locking—stronger!

MORE ECONOMICAL—Now, for the first time, new Slotted-Type Place Bolts can be made of carbon as well as alloy steels—making possible savings in costs on all applications wherever a locking bolt is needed.

SELF-LOCKING—Place Bolt's spring-action head, tightened against a rigid seat, locks the bolt against all involuntary loosening influences including vibration, and insures against impact of shock failure.

STRONGER—One-piece, all-metal, new Slotted-Type Place Bolts now have reinforced continuous-grained heads that increase their yield and fatigue strength.

In any typical application such as connecting rod bolts, main bearing cap screws, flywheel bolts, and piston pin lock screws, the new "National" Place Bolts can help you solve those critical problems of fatigue and involuntary loosening in automotive, aircraft, farm equipment and other assemblies.

"National" Slotted-Type Place Bolts may be used with nuts, or in tapped holes. They can be made in a wide range of sizes and can also be modified for special applications.

We'll gladly send you more details and prices. Write:

U. S. Patent No. 2543705

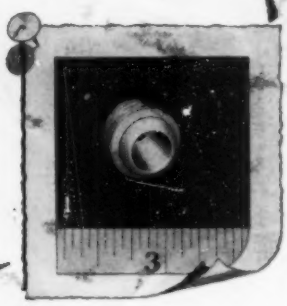
THE NATIONAL SCREW & MFG. CO.
2440 East 75th St. · Cleveland 4, Ohio
Pacific Coast: National Screw & Mfg. Co. of Cal.
3423 South Garfield Ave., Los Angeles 22, Cal.

National
STUDS AND THREADED
PRODUCTS

for
product improvement
ideas consider

nylon

rod and strip



This valve seat machined from FM-10001 nylon rod outlasts 3 to 5 seats made from metal. Because of its resiliency, plus resistance to abrasion and corrosion, this nylon seat is practically "leakproof". Machining was readily handled on metalworking equipment.

Nylon formulations with properties tailor-made for specific applications are available, and will provide the performance you need. Many products such as valve seats, bearings, gears, instrument and control parts are now being made from several nylon formulations, because of the material's outstanding physical properties.

Nylon rod and strip made to meet your job requirements can give you important savings in fabrication. You start production immediately, right from the blueprint. No waiting for expensive molds. Design changes can be made quickly, and the tooling costs are low.

New Folder Describes Types and Sizes Available . . .

Just drop us a line for your free copy of this folder describing various nylon formulations, sizes available, etc.

THE POLYMER CORPORATION
Reading, Pa.

NYLON & TEFLON
ROD
STRIP
TUBING

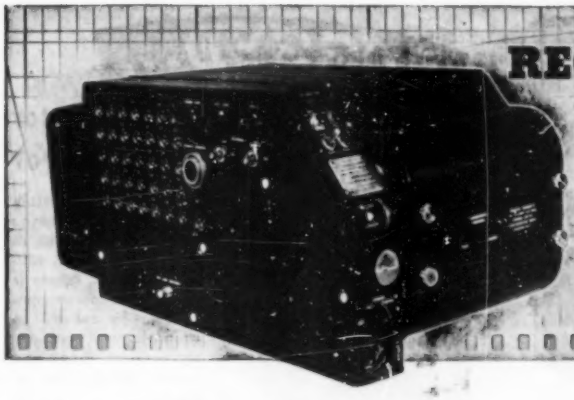
Pioneer Producers of Nylon Rod and Strip

NEED ? DESIGN ENGINEERS ?

They—and their assistants—are the readers of this magazine. You can hire them by placing a "position vacant" advertisement where they are sure to see it—in our classified section starting on page 441.

PRODUCT ENGINEERING

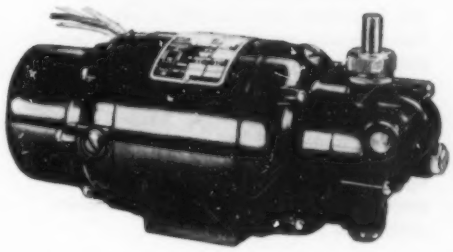
To tap this manpower market, just send in your advertisement before March 16 directly to us at 330 W. 42nd St., N. Y. 18, N. Y.



RECORDING OSCILLOGRAPH uses a BODINE MOTOR

Any phenomenon capable of being converted into an electrical quantity may be recorded against time by the Consolidated Recording Oscillograph. As many as 18 separate channels of static or dynamic data can be recorded simultaneously on a single strip of photographic paper or film seven inches wide. The record magazine, containing the paper or film, is driven by a dependable, governor-controlled Bodine Motor.

While the oscillograph records data to evaluate the performance of certain products, the evaluation of motor cost involves such considerations as motor rejections, repair and service charges, motor failures, and repeat sales. You cannot afford less than the best motor.



Satisfied users, for nearly half a century, are responsible for the fine reputation of Bodine Motors. The long range repeat sales–profit motive is one of the many "reasons why" you, too, should select a Bodine Motor for your product. You'll find it convenient and economical to do so, for Bodine offers over 3,500 standard motor specifications. Help from experienced engineers is yours for the asking.

BODINE ELECTRIC COMPANY
2260 W. Ohio St.
Chicago 12, Ill.

REASONS WHY
"Our selection of the Bodine motor for our new oscillograph was based on the following reasons: 1—Satisfactory performance of Bodine motors for many years in an earlier type recording oscillograph. 2—Found Bodine motors to be of superior quality and extraordinarily conservative in design. 3—We have never had evidence of failure in service of any Bodine motor, even under the most adverse conditions to which our Recording Oscillographs have been subjected. 4—We have the very highest regard and appreciation for the cooperation and ability of your sales and engineering staff."
Consolidated Engineering Corp.
Pasadena, Calif.

THE POWER BEHIND THE LEADING PRODUCTS

DISTRICT AGENTS

BUFFALO 3, N. Y.
Ellicott Square—S. E. Shea

CAMBRIDGE 39, MASS.
686 Massachusetts Ave.—W. A. Black

CLEVELAND 3, OHIO
4500 Euclid Ave.—W. R. Uffelman

DETROIT 1, MICHIGAN
4464 Cass Ave.—C. D. Miller

KANSAS CITY 6, MISSOURI
903 McGee Street—T. Pollmounter

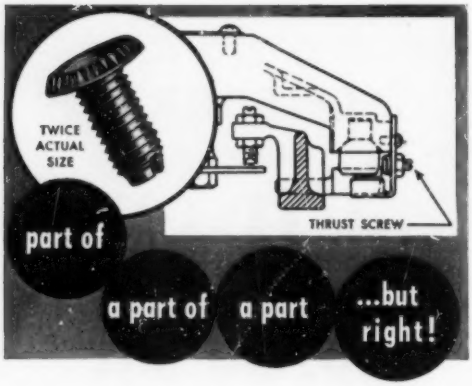
LOS ANGELES 13, CALIF.
411 So. Wall St.—H. M. Hall

MINNEAPOLIS 15, MINNESOTA
712 Sixth Ave., So.—A. C. Jacobson

NEW YORK 18, N. Y.
55 West 42nd St.—H. C. Mayorga

ROCHESTER 4, N. Y.
825 Commerce Bldg.—S. E. Shea

SAN FRANCISCO 3, CALIF.
995 Market St.—J. F. Cady



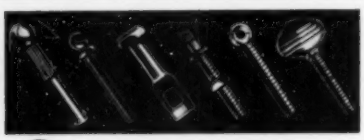
This Progressive-made fastener is one of the many precision parts in the Toledo Scale Company's Guardian Duplex scale. It is used as a thrust screw in the main lever assembly for making fine adjustments.

Hardly a major part, but still it must be right. "Honest Weight" is Toledo's business and precision is required right down to the smallest component.

Manufacturing precision fasteners is Progressive's business, as leading companies well know. If you need a special fastener manufactured in quantity to exact specifications, see Progressive.

WRITE FOR OUR CATALOG
IT MAY SAVE YOU MONEY

Other typical **PROGRESSIVE** *"Specials"*



QUALITY PROMCO BRAND

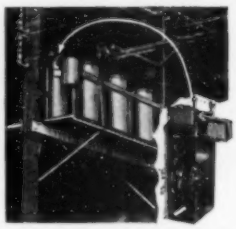
THE PROGRESSIVE MANUFACTURING COMPANY

48 NORWOOD ST., TORRINGTON, CONN.

SALES OFFICES: SAN FRANCISCO, LOS ANGELES, PORTLAND, DETROIT, PHILADELPHIA, CLEVELAND, SEATTLE, BOSTON, SYRACUSE, ST. LOUIS, CHICAGO.

RUGGED...

Reversible BARCOL Motor Drives Voltage Regulator



Three-Wire Reversible *Barcol* Geared Motor drives tap changer in Allis-Chalmers JFR voltage regulator. Motor is designed to operate completely immersed in transformer oil over wide temperature range and under rapidly varying loads.

Other Applications for Barcol Low-Inertia *FAST-REVERSING* Motors:

- SERVO MECHANISMS
- TELEVISION TUNERS
- RADIO TUNERS
- ANTENNA ROTATORS
- RECORDER PEN DRIVES
- X-RAY CONTROLS
- pH CONTROLLERS
- SHIPS' LOGS
- AIRCRAFT TRAINERS

OTHER REVERSIBLE SHADED POLE MOTORS:

With and without Gear Reductions.

Enclosed and Open.

Adaptable to 2-Phase power supply, capacitor operation and electronic control.

Write for Catalog

Other Barcol Motors: Unidirectional, Synchronous, and Asynchronous; Geared and Non-Geared. Write for data.

BARBER-COLMAN COMPANY • ROCKFORD, ILLINOIS

Type "B" Pressure Reducing and Regulating Valve

There's a CASH-ACME Automatic Valve to handle anything that flows —Water, Air, Steam, Gases, Chemicals, Refrigerants, Oil, Gasoline and all other types of liquids.

Steam Equipment Manufacturers Specify CASH-ACME!

In any industry that requires consistent pressure control, CASH-ACME is specified by more and more manufacturers. Write today and find out how a CASH-ACME Automatic Valve can help with the successful operation of your product.

CASH ACME SILENT SENTINEL *Automatic Valves*

A. W. CASH VALVE MANUFACTURING CORP.
6662 E. Wabash Avenue
Decatur, Illinois

ZAPON Can Help You Meet Finishing "Specs"

DEFENSE ORDERS bring with them the problem of finishes that meet government "specs." You can get the help you need from ZAPON.

ZAPON technicians keep up to date on government specifications. They bring you finishes that not only meet government "specs" in the drum, but comply with all the performance requirements.

Let ZAPON *Service From Every Angle* help you set up your finishing department to fill government orders with speed and economy. ZAPON technicians will tackle any problem of "conformance" on your own production line.

Service from every angle... that's ZAPON

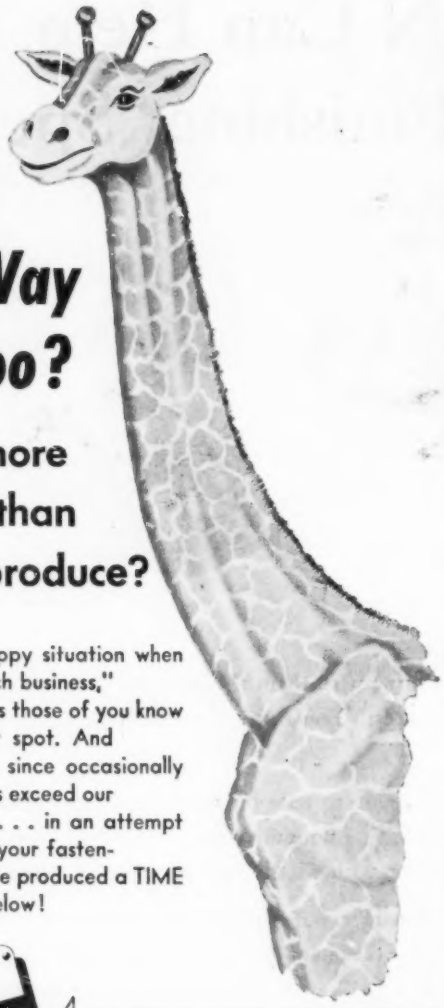
REG. U.S. PAT. OFF.

ATLAS POWDER COMPANY

Industrial Finishes

Stamford, Conn. • North Chicago, Ill.

Is YOUR Neck Way Out, Too?



...with more business than you can produce?

Sounds like a happy situation when you say "too much business," but it sure isn't, as those of you know who are on that spot. And we're on it, too, since occasionally your requirements exceed our production. But . . . in an attempt to help you with your fastening problem, we've produced a TIME SAVER, shown below!

FREE—A-N Stainless Fastening Selector

This handy slide-chart instantly identifies A-N Nos. pertaining to stainless steel nuts, screws, bolts, rivets, cotter pins, washers; gives sizes and other data. Write for "Chart 51S" TODAY!

Anti-Corrosive Metal Products Co., Inc.

Manufacturers of **STAINLESS STEEL FASTENINGS**

CASTLETON-ON-HUDSON, NEW YORK

RECENT BOOKS *for the* *Product Engineer*

See them 10 days FREE

PROCESS ENGINEERING

By William H. Schutt
Wm. H. Schutt Associates, Detroit

1. This book shows you how to establish the proper sequence of operations and exact labor cost *directly from the blueprint* . . . how to determine the quantity and cost of materials to be used . . . how to plan efficient tools, dies, jigs, and fixtures for economical production. Here's a money-saving book that eliminates guesswork in cost-estimating.

308 pages, $4.50

MACHINE DESIGN

By Paul H. Black
Prof. of Machine Design, Cornell University

2. Here is a complete discussion of each phase of machine designing, from the adaptability and selection of materials for the various machining processes to the elimination of vibration . . . practical aids, hints and suggestions on everything from good form in making machine-design computations to detachable machine fastenings.

Includes Full Treatment of Stress Concentration

Making the book unique is the complete treatment it gives to stress concentration—its applicability—seriousness—mitigation—determination—and design application.

334 pages $5.00

Engineering Applications of

FLUID MECHANICS

By J. C. Hunsaker,
Dept. of Aeronautical Eng., M.I.T.
and B. G. Rightmire,
Dept. of Mech. Eng., M.I.T.

3. Here is an unusually detailed book applying the important basic principles of fluid mechanics to everyday problems. It makes use of advanced, improved methods to analyze problems and equipment involved in fluid flow . . . covers hydraulic circuits and servomechanisms. Here are diagrams, formulas and equations necessary for a complete understanding of fluid mechanics . . . presented in easy-to-follow form for a quick understanding of the principles involved.

487 pages $6.50

10 DAYS' FREE EXAMINATION

McGraw-Hill Book Co., Inc., 330 W. 42d St., NYC 18

Send me book(s) corresponding to the numbers encircled below for 10 days' examination on approval. In 10 days I will remit the price of the book(s) I wish to keep, plus a few cents delivery charge and return unwanted books postpaid.*

1 2 3

Name .....

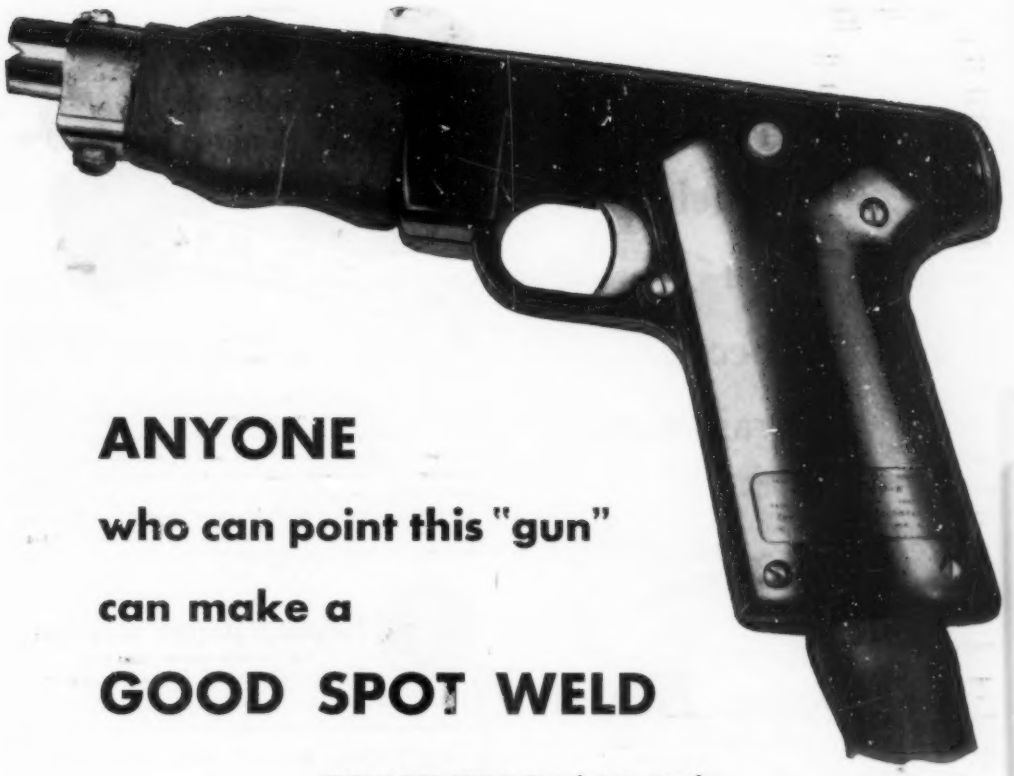
Address .....

City .....Zone....State .....

Company .....

Position PPE-9-51

* SAVE! We pay mailing costs if you send cash with this coupon. Same return privilege.



ANYONE

who can point this "gun"

can make a

GOOD SPOT WELD

"HELIARC" HW-8 Pistol-Grip Torch needs no forging pressure... works from one side of sheet... spot welds both STAINLESS and CARBON STEELS

Are you using light gage metals to fabricate large assemblies or irregular shapes? If so, chances are you can simplify many of your joining problems, boost production, and cut costs, too, by spot welding with the HELIARC HW-8 Torch.

The HW-8 joins mild steel, low alloy, or stainless steel .020 to .064 in. thick at one to two seconds per weld. Because it works *from one side of the sheet*, without forging pressure, it makes an easy, one-hand job of spot welding — even in places where resistance welding is not practical or possible.

Connected to a suitable power source with auxiliary timer, the HELIARC Spot Welding Torch makes inert gas shielded welds without fumes, smoke, or spatter. Since operation is automatically controlled, workmen on the assembly line need only press the "muzzle" of the "gun" against the work and pull the trigger. A single hose assembly permits free use of the torch over a 25-ft. radius.

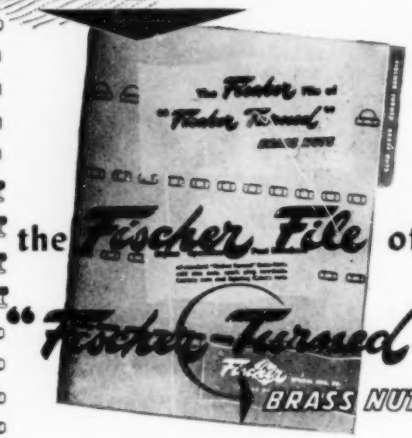
For further information, telephone or write today. LINDE AIR PRODUCTS COMPANY, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y.

The term "Heliarc" is a registered trade-mark of Union Carbide and Carbon Corporation.

Linde Trade-Mark

Products and Processes for MAKING, CUTTING, JOINING, TREATING, and FORMING METALS

"specs" to help you specify brass nuts



the Fischer File of "Fischer-Turned" BRASS NUTS

Send for this time-saving file today. Its 16 pages are filled with charts on Pitch Diameter Tolerances, explanations of American and Unified Thread Limits, styles, specifications and part numbers of standard brass nuts and other helpful technical data.

It's designed to fit and be found easily in a standard file drawer and has a handy pocket flap to hold supplements and other fastening information. Send for yours today.

MAIL THIS COUPON TODAY! P-1

Fischer SPECIAL MFG. CO.

"Turned Products Since 1905"

CINCINNATI 6, OHIO

Send me your new Fischer File

Name _____ Company _____

Address _____ City _____ Zone ____ State _____

Skinner Solenoid Valves

M-2 Bronze Body Diaphragm Valves M-3

for air conditioning, packaging, refrigeration, air, printing equipment, etc.

The "M" Series valves are approx. 4⅛" high, yet have extremely fast action and large capacity for liquids, air and inert gases! They have soft insert seats to prevent leakage — will operate in any position — nylon fabric coated diaphragm for long life — max. power consumption 10 watts — continuous duty! M-2 two-way normally closed — 5 to 150 p.s.i. — port size ⅜" or ½"; orifice ⅜" — pilot operated. M-3 three-way normally closed, three-way normally open or directional flow — 20 to 150 p.s.i. — port size ⅜" or ½"; orifice ⅜" — pilot operated. Special models available.

Write for Bulletin No. 493

Skinner ELECTRIC VALVE DIV.
THE SKINNER CHUCK COMPANY
132 Belden Ave., Norwalk, Conn.

CUSTOM BUILT MACHINERY
FOR OVER 75 YEARS

DIXIE-COWDREY
Machine Corporation

(A subsidiary of the Dixie Cup Co.)

Write:
DIXIE-COWDREY
Fitchburg, Mass.
Telephone: Fitchburg 5200

DESIGNERS AND BUILDERS OF SPECIAL PURPOSE MACHINERY

LEFAX POCKET SIZE TECHNICAL DATA BOOKS $1. EACH

Printed on loose leaf, six hole, 6-3/4" x 3-3/4" bond paper, each book contains about 140 pages of technical data, presenting condensed, accurate and essential data for the student, engineer, technical worker and business man.

Architecture
Home Heating
Illumination
Electrician's Data
Builder's Data
Lumber Data
Air Conditioning
General Math.
Math. Tables
Physics
Chemical Tables
Metals
Gen'l. Chemistry
Reinf. Concrete
Building Constr.
Radio
Television & FM
Electricity, AC
Electricity, DC
AC motors and Generators
Transformers, Relays, Meters
Hydraulics
Surveying
Mech. Drawing
Machine Design
Machinists Data
Piping Data
Surveying Tables
Trig-Log Tables
Metallurgy
Analytic Chemistry
Highway Engineering
Mech. of Materials
Pwr. Trans. Mchy.
Thermodyn. Tbls & Charts
Phys. & Thermodyn. Data
Phys. & Org. Chem.

Write for FREE Catalog (over 2000 listings.) See for yourself how helpful LEFAX can be to you. Send $1. for each book, or $5. for any six books listed above, to:

LEFAX DEPT. PE-9 Philadelphia 7, Pa.

What's U.S. Rubber doing to prevent spool breakage?

The spools on this wire coating machine are made of Uscolite, U.S. Rubber's new plastic. They can deform under loads without breaking to a greater extent than metals can.

PRODUCT OF

U.S.RUBBER

SERVING THROUGH SCIENCE

This Uscolite pipe was only dented after being hit by a .44 calibre revolver bullet fired from 20 yards. This amazing plastic is light in weight, extremely versatile.

● "U.S." makes spools of Uscolite, a remarkable plastic which is replacing many other materials, including other plastics. These spools do not chip and get rough around the edges, as do metal spools. Uscolite spools have low thermal conductivity hence wire spooled when hot stays tight upon cooling. A wide variety of products are made of Uscolite, including many types of piping. This great material is resistant to most chemicals, has high impact strength, is furnished in standard lengths; pipe can be cut to size and threaded on the job. For more information write to address below. In Canada, write to Dominion Rubber Company, Montreal.

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

HELI-COIL SCREW THREAD INSERTS SIMPLIFY DESIGN AND ASSEMBLY

These stainless steel wire inserts, precision-formed to assure Class III fit, permit simpler design, lighter weight, fewer bolts, shorter thread engagements... eliminate costly solid bushings, provide lighter boss and flange design, improve all threaded products. Heli-Coil Inserts fit National Coarse and Fine Threads, automotive and aviation spark plugs, and taper pipe threads. Meet all aircraft, industrial and military specifications.

Cost is 75% less than solid bushings, space required 50% less. There is no wear from assembly and disassembly, however frequent. Strength is greater and product is completely free from screw-thread complaints for product service life.

HELI-COIL CORPORATION

Heli-Coil is a registered U. S. Trademark

Protecting Screw Threads for Industry

Heli-Coil Corporation
Danbury, Connecticut

Please send me ☐ Bulletin 650 on Design Data
☐ Bulletin 349 on Salvage & Service

NAME.....

FIRM.....

STREET.....

CITY.....ZONE.....STATE.....

There *is* an easier way . . .

There's only one simple symbol to check when you order

Bond STOCK GEARS

You won't need calipers or slide rule when you order Bond Stock Gears. Every gear in our comprehensive line is identified by a simple symbol—a symbol that tells us exactly and unmistakably what you are ordering.

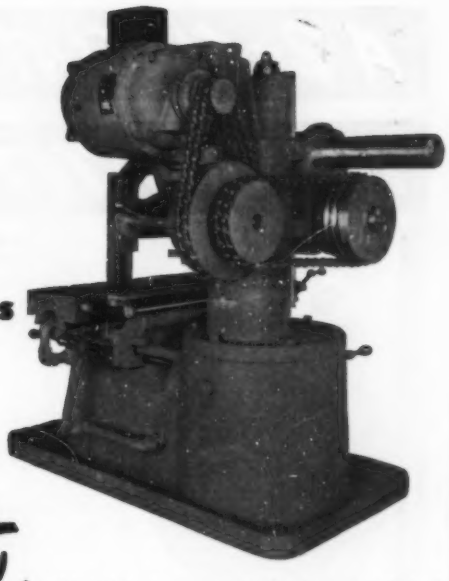
Easy ordering is only one of the advantages of using Bond Stock gears for replacements—or as original equipment. You get quicker delivery, too, because far less time is required to take a gear out of stock than to make it to special order. You also save money, because hours of highly paid skilled labor are needed to produce a special gear.

Start right now to save on gear replacement costs and ordering time. Write for Bond Stock Gear Catalog No. 65 today.

Carried in stock by
DISTRIBUTORS IN PRINCIPAL CITIES
(Write for name of nearest distributor)

CHARLES BOND CO.
617-21 Arch Street, Philadelphia 6, Pa.

Bond
STOCK GEARS
SPEED REDUCERS



design your v-belt drives

without the usual limitations

...specify Veelos, the adjustable v-belt

Anything that gives you more freedom, more latitude in designing machinery—and still saves you money—is welcome. That is why we say: consider Veelos, the *adjustable* v-belt, when you are designing a v-belt drive.

Veelos in the design means you *can* place the motor in the most advantageous position.

Veelos in the design means you *can* use outboard bearings where desirable because this belt is installed without dismantling any part of the machine.

Veelos in the design means you *can* have fixed center drives.

Veelos in the design means you *can* save money by the elimination of idlers, pivoted or sliding type motor bases.

Veelos in the design means that correct belt tension, important for full, vibrationless power delivery, *can* be constantly maintained.

Veelos v-belt is made in all standard widths: 3V, 5V, A, B, C, D and E. It is available in three types: regular, oil-proof and static conducting. Also Veelos double V in A and B widths.

Our engineers are always glad to help you find the answer to your v-belt needs so call upon them anytime. Let us send you a copy of the Veelos Data Book—it is full of important facts.

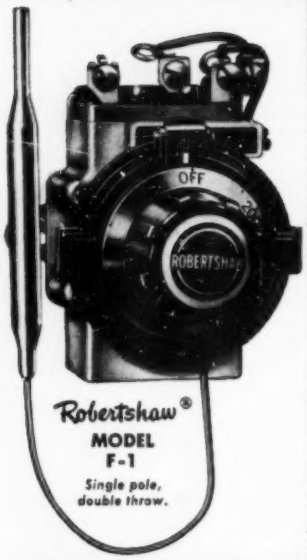
MANHEIM MANUFACTURING & BELTING COMPANY • MANHEIM, PA.

VEELOS
THE LINK
V-BELT

Adjustable to Any Length • Adaptable to Any Drive

Veelos is packaged on reels in 100-foot lengths. Sales engineers in principal cities; over 350 distributors throughout the country. VEELOS is known as VEELINK outside the United States.

A 2-CIRCUIT THERMOSTAT



Robertshaw®
MODEL
F-1
Single pole, double throw.

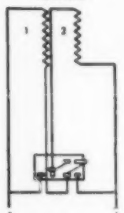
For a Thousand Uses

When Model F-1's thermostat calls for heat, high heat element automatically cuts in and holds until set temperature is reached. On reaching set temperature, main contacts are automatically broken, and low, or holding temperature element is cut in to function until drop in temperature again calls for heat.

May be used to operate fans in air ducts or agitators in tanks, etc., where such operations in combination with heaters are required. *Write for Catalog F-1.*

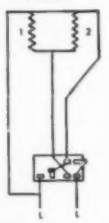
Wiring diagrams shown do not constitute a warranty against patent infringement arising from use of circuit shown.

Fig. 1
Requires Special Terminals



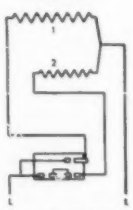
Wiring Diagram for Two Independent Heater Elements. (With Rise in Temp. Circuit Changes from Parallel to Series.)

Fig. 2
Requires Special Terminals



Wiring Diagram for Two Heater Elements. With Common Lead. (With Rise in Temperature, Circuit Changes from Parallel to Series.)

Fig. 3
Standard

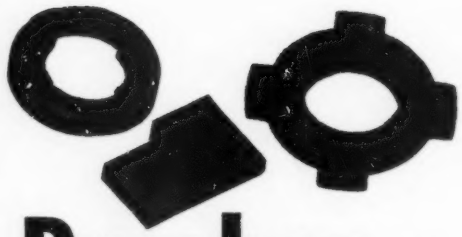


Wiring Diagram for Two Circuit Connection. With Rise in Temp. Circuit Operates from 2 on to 1 Off, to 2 Off to 1 On.

In Home and Industry, *EVERYTHING'S UNDER CONTROL*

Robertshaw

THERMOSTAT DIVISION
ROBERTSHAW-FULTON CONTROLS COMPANY
YOUNGWOOD, PENNSYLVANIA



Purebon
solves many problems

caused by sliding or rotating parts which are difficult or impossible to lubricate

A constantly increasing stream of problems are facing engineers and designers today involving sliding or rotating parts where lubrication is difficult or impossible. For such applications, Purebon, the mechanical carbon, is often the ideal answer. Typical applications are seal rings, bearings, pistons, piston rings, pump vanes, valve seats, meter discs, and a host of similar items. Purebon comes in a wide variety of grades. It is strong, tough, readily machineable and in many cases can be molded directly to size.

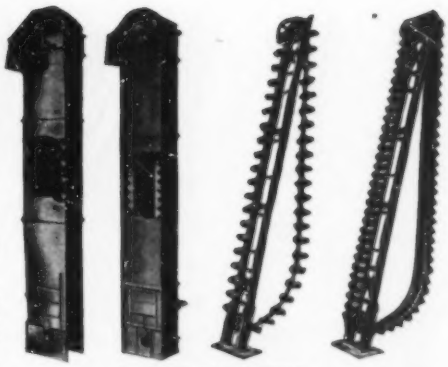
Bulletin No. 482 tells the complete story of Purebon. Write for your copy today.

PURE CARBON CO., INC.
448 HALL AVE. ST. MARYS, PA

Partial List of

WHAT WE MAKE

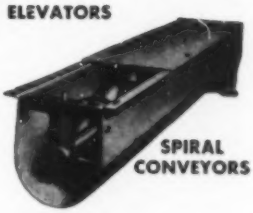
TO HELP YOU IN YOUR HANDLING AND PROCESSING OPERATIONS



BUCKET ELEVATORS

Check these items . . . likely you need one or more right now. We build a complete line of equipment for handling, processing and reducing all kinds of material. We cannot show everything Jeffrey builds to speed production and cut costs, but send for Booklet No. 832 for a quick picture of our extensive line. Jeffrey's engineering facilities are available for laying out complete handling and processing systems or the application of individual units.

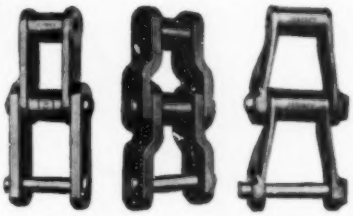
BELT CONVEYORS—IDLERS



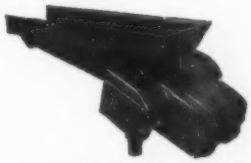
SPIRAL CONVEYORS

SCRAPER CONVEYORS

For handling bulk material horizontally or on incline, discharging at fixed point through valves in trough bottom. Also wood or steel Apron Conveyors.



CHAINS SPROCKETS ATTACHMENTS



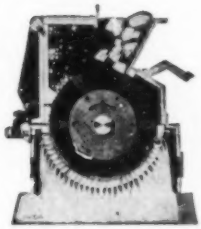
FEEDERS—CONVEYORS

A wide range of sizes and types in electric vibrating feeders, conveyors, screens, packers, etc. Absolute control over tonnage handled.

M-V MECHANICAL VIBRATING CONVEYORS

For conveying abrasive, lumpy or rough materials, hot or cold, dry or wet, as well as fine materials. Up to 80′ can be operated by one drive unit. Also electric vibrating conveyors, feeders, screens and packers.

More detailed information on request.



CRUSHERS—SHREDDERS GRINDERS—PULVERIZERS

BARREL PACKERS

For economy in packing operations—reduce size of container, increase its capacity and cut shipping costs. Also conveyor-type packers and packing tables.

THE JEFFREY MANUFACTURING COMPANY

Established 1877

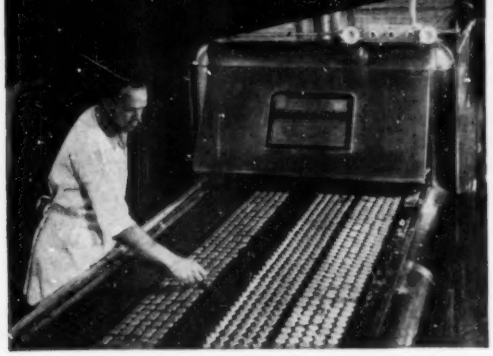
788 North Fourth St., Columbus 16, Ohio

Complete Line of Material Handling, Processing and Mining Equipment

Baltimore 2 · Beckley, W. Va. · Birmingham 3 · Boston 16 · Buffalo 2 · Chicago 1 · Cincinnati 2 · Cleveland 15 · Denver 2 · Detroit 13 · Forty Fort, Pa. · Harlan, Ky. · Houston 2 · Jacksonville 2 · Milwaukee 2 · New York 7 · Philadelphia 3 · Pittsburgh 22 · St. Louis 1 · Salt Lake City 1

Jeffrey Mfg. Co. Ltd., Montreal, Canada
British Jeffrey-Diamond Ltd., Wakefield, England
Jeffrey-Galion (Pty.) Ltd., Johannesburg, S. A.
The Galion Iron Works & Mfg. Co., Galion and Bucyrus, Ohio
Galion (Great Britain Ltd.), Wakefield, England
The Ohio Malleable Iron Co., Columbus, Ohio
The Kilbourne & Jacobs Mfg., Columbus, Ohio

conveyor belt for canine cookies--



Imagine your dog's delight on seeing a solid column of biscuits 160' long and 42" wide! That's the carrying surface of this Cambridge Woven Wire Conveyor Belt in a recirculating oven at Kendall Foods Company, Bell Gardens, California.

Balanced Weave, specified for this installation, is low in cost, eliminates creeping of the belt on the drive pulley, and provides high tensile strength. Open mesh of the belt allows free circulation of heat within the oven . . . crumbs and broken bits of biscuit fall through the belt, cannot foul up automatic packaging equipment at the end of the oven.

Whether you're baking biscuits, processing meat or canning vegetables, there's a Cambridge Woven Wire Conveyor Belt to help mechanize your production. Stainless steel to meet sanitary codes is a standard material of construction for our food plant customers. Call in your Cambridge field engineer today, let him explain the superior construction features of **Cambridge Woven Wire Conveyor Belts . . .**

The Cambridge Wire Cloth Co.

Dept. P • Cambridge 9, Md.

WIRE CLOTH · METAL CONVEYOR BELTS · SPECIAL METAL FABRICATIONS

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

See "Plating - Mechanical" in your Classified Telephone Directory.

WRITE FOR FREE MANUAL illustrating and describing conveyor belt installations for food, metalworking, chemical, ceramic and other processes.

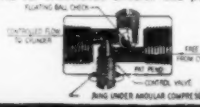
FLOW CONTROL VALVE

for Cylinder Speed Adjustments

OVER A WIDE RANGE IN AIR OR HYDRAULIC USE

The Pneu-Trol Flow Control Valve combines an efficient Stainless Steel FLOATING BALL CHECK which opens and closes at the slightest change in flow direction, with a Vernier Type VARIABLE NEEDLE ORIFICE adjustment in a compact control which has widened air and hydraulic cylinder application by providing precise control of cylinder action. Modifications of the Pneu-Trol Valve are available as Plain Check, check with Fixed Orifice (orifice drilled by customer in the Standard Check Valve), Needle Valve and Velocity Limiting Check, as illustrated at left. All Pneu-Trol Valves are made from bar stock in brass (up to 1000 psi) or steel (5000 psi) or other body metals to your specifications. All internal parts are Stainless. All valves available in 5 sizes—⅛", ¼", ⅜", ½" and ¾".

Attractive prices — immediate delivery. Write for illustrated circular and price list.



WRITE

Pneu-Trol Devices, Inc.

1428 N. Keating Ave., Chicago, Ill.

STAMPINGS IN SMALL LOTS

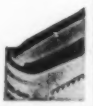
PRECISION DIE MADE — LOWEST POSSIBLE COST

DAYTON ROGERS MFG. CO.

Minneapolis 7, Minnesota

How to estimate the time any machining job will take

Whether a job involves drilling, boring, tapping, threading, grinding—or any other operation—this manual tells you exactly what to consider in estimating job-time. It covers every step—from setting up the job, to tearing it down—giving reasonable time values for each, based on actual experience.



MACHINE-SHOP ESTIMATING

BY W. A. NORDHOFF

SEE IT 10 DAYS FREE

McGraw-Hill Book Co., Inc., 330 W. 42 St., NYC 18

Send me Nordhoff's MACHINE-SHOP ESTIMATING for 10 days' examination on approval. In 10 days I will send $6.50, plus few cents for delivery, or return book.

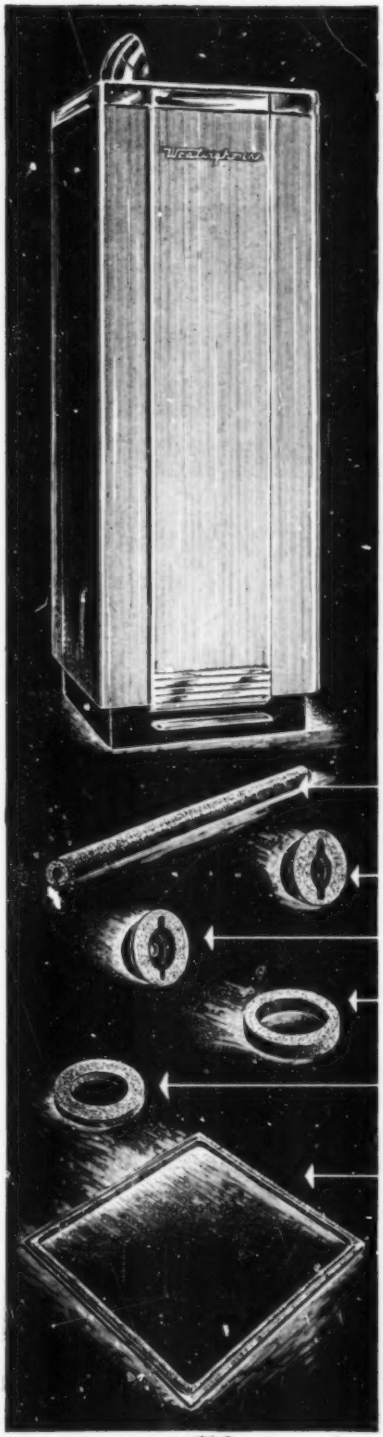
Name .....

Address .....

City ..... Zone..... State.....

Company .....

Position PPE-9-51



This water cooler
has a Longer, Better Life... works less each day

with **SPONGEX®**

CELLULAR RUBBER

Corrosion...deterioration...mechanical failure...repairs and parts replacement—an inevitable sequence wherever moisture condensation collects. It's a problem particularly troublesome in refrigerating equipment—but not in this Westinghouse water cooler!

Westinghouse has given its cooler a wardrobe of Spongex cellular rubber. Exposed cold surfaces—tubing, valves, even the waste water drain—are covered by custom molded Spongex parts. These Spongex parts not only prevent condensation but their insulating qualities increase refrigerating efficiency. For this cooler, Spongex means a longer, better, more efficient life.

The Westinghouse Wardrobe of SPONGEX

Tube insulator—
covers cold water tubing that supplies the drinking bubbler.

Regulator valve cap—
covers the cold surfaces of valve. Elasticity and flexibility of cap makes it easily removed for valve adjustment.

Water valve cap—
covers shut off valve controlling water flow to bubbler.

Basin drain insulator—
covers exposed end of the waste water drain.

Basin drain seal—
forms a water tight seal between bottom of the water cooler basin and top of the drain. The compressibility of Spongex compensates for variations in the clearance between basin and drain.

Door gasket—
forms an air tight seal for the door opening into the cold storage compartment. The gasket also seals off the insulating air space between the inner and outer panels of the door.

Perhaps Spongex can help better your product, too. We would be happy to hear from you.

The World's Largest Specialists in Cellular Rubber

THE SPONGE RUBBER PRODUCTS COMPANY
402 Derby Place, Shelton, Connecticut

Nth DEGREE ACCURACY

...ONE INCH TO ONE MILE!

Precision Made Bourdon Gauge Tubing meets and beats most exacting requirements . . . performance tests.

Nth DEGREE LABORATORY CONTROL

"Precision Control" safeguards absolute accuracy of size of tube and wall thickness . . . plus the development of exact uniformity of the structure of the metal so essential to long life of pressure spring tubing.

Nth DEGREE HEAT TREATING

"Precision Control" in heat treating is achieved in exclusive bright annealing, atmospherically controlled furnaces. The precision exercised in attaining metallurgical specifications makes possible a tubing which is outstandingly high in fatigue resistance.

Nth DEGREE ACCURACY IN TESTING

"Precision Controlled" inspection carefully checks to the Nth degree every inch of tubing produced. Precision produces Bourdon Gauge Tubing to specifications with any non-ferrous metal. It is available in all bourdon shapes, in cut or random lengths. Obtainable on good delivery.

WHEN PRECISION COUNTS . . . COUNT ON PRECISION

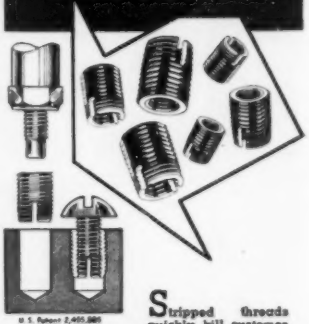
Aluminum alloy instrument tubing to exact specifications . . . preformed tubing to suit your needs . . . Coaxitube—the metal shielded wire for a 1001 electronic uses. Write for complete catalog today.

PRECISION TUBE CO.

PRECISION

Factory: 3824-26-28 TERRACE STREET, PHILADELPHIA, PA.

TAP-LOK INSERTS save Man-hours and Customers



U. S. Patent 2,405,805

Stripped threads quickly kill customer goodwill. To prevent tapped thread failure in light metals, plastics, wood and similar materials, sound engineering calls for some form of hard bushing to increase the shear area. Among the various types available, TAP-LOK INSERTS have several important advantages:

(1) Self-tapping, they save many man-hours in assembly, in continuous production.
(2) They hold rigidly in position.
(3) Their cost is relatively low.

The TAP-LOK INSERT is quickly installed with a simple driving tool into a cored or drilled hole equal in size to a tap drill hole for the external thread of the insert. It cuts its own thread, saving the cost of a separate tapping operation. It remains secure because the torque necessary to dislodge it is greater than the torque a standard machine screw can withstand. It suffers none of the uncertainties and losses in assembly that accompany the use of molded-in and cast-in inserts.

Send for samples and descriptive folder.

•

Also manufacturers of Groov-Pins—for positive locking press fit.

GROOV-PIN

GROOV-PIN CORPORATION

1121 HENDRICKS CAUSEWAY
RIDGEFIELD, NEW JERSEY

HITS A HIGH NOTE IN PERFORMANCE

The secret of *outstanding* symphony performance can be traced to the skill of the conductor. The talent of each individual musician must be coordinated with all the others for perfect balance and exact timing.

In the design and manufacture of Emerson-Electric Motors, there is no secret reason for their *outstanding* performance. Specifications require that each component part be soundly constructed, and that all the parts must operate together, harmoniously, to give efficient, exacting service.

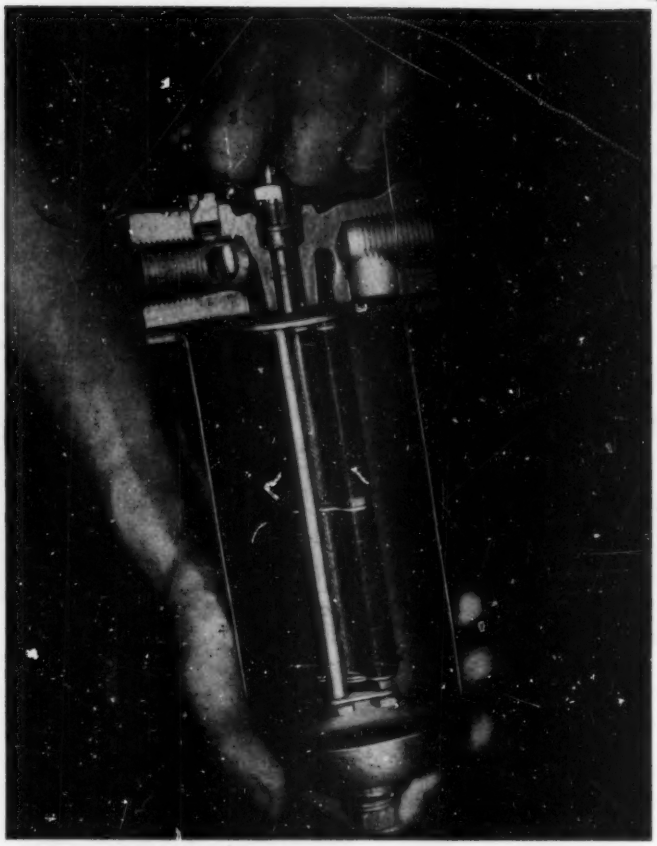
Many of America's leading appliances and products are powered with Emerson-Electric Motors. Their manufacturers have discovered that the smooth operation of Emerson-Electric Motors is an *outstanding* factor in building sales. Your inquiry for full information, without obligation, is invited. Write today.

EMERSON-ELECTRIC'S unique *Twingineering* SERVICE solves your power problems

Emerson-Electric Engineers are eager to collaborate with your own staff in designing and providing the proper motor application to your new or improved appliance or equipment. "TWIN-GINEERING" can save you costly engineering "back-tracking," and may suggest short cuts or improvements of great competitive benefit to your product. Write today for Free bulletin No. 152.

THE EMERSON ELECTRIC MFG. CO., St. Louis 21, Mo. 22

EMERSON ELECTRIC
MOTORS • FANS APPLIANCES



You Can Clean This Fluid Strainer Without Stopping the Flow

Cuno AUTO-KLEAN is the *only* fluid strainer with "comb-action cleaning" which permits it to work uninterruptedly. Dirt accumulations are dislodged *while* the straining goes on. This can be done automatically. *Guaranteed* to remove 100% of all solids larger than specified.

A Lot of Dependability in a Small Package

Thousands of industrial firms recognize the Cuno AUTO-KLEAN disc-type strainer as an indication of *protection* on lube and hydraulic systems.

They know the machine builder has provided the best means of keeping fluids *clean* . . . when he has installed the AUTO-KLEAN as standard equipment.

They appreciate, too, the ease with which the AUTO-KLEAN works. A turn of a handle—periodically by hand or continuously by automatic means—is all that is necessary to keep the strainer *itself* clean. This is done without stopping flow. And there's nothing to replace or renew.

They also know that the AUTO-KLEAN is *guaranteed* to remove 100% of the solids larger than specified*. . . with minimum pressure drop.

The Favorite of Designers

The Cuno AUTO-KLEAN solves other problems *right on the board.*

It's compact. A single unit handling full flow (from a few to more than 4000 gpm) occupies no more space than the usual partial-flow type.

You can build it in—or mount it externally. Inlet and outlet can be in any position. You can install it on low pressure or gravity feed or suction with no loss of efficiency.

And you can depend upon it lasting as long as the equipment on which it is installed because it is all-metal and non-collapsible and can be made of a wide range of materials for various fluids, viscosities, temperatures and solids to be handled.

*Available spacings from .0035 in. to .062 in.

Cuno Engineering Corporation
Dept. 301A, South Vine St., Meriden, Conn.
Please send information on Cuno AUTO-KLEAN
for .....
Name .....
Company .....
Address .....
City ..... Zone .... State ....
Please attach to business letterhead

CUNO

Fluid Conditioning

Removes More Sizes of Solids from More Kinds of Fluids

Strain fuels, lubricants, process fluids, etc.—AUTO-KLEAN
Filter fuels, lubricants, process fluids, etc.—MICRO-KLEAN
Clean raw water, recirculating water, etc.—FLO-KLEAN

Janette MEANS DEPENDABLE SPEED REDUCTION

"the right speed, the right power"

Dependable performance has made JANETTE Motorless Speed Reducers the first choice of plant operators and manufacturers who insist upon the best.

▪ Simply designed, sturdily built ▪ Positive ratio of speed reduction ▪ Long service life ▪ Wide adaptability ▪ Compactness ▪ Ease of installation

JANETTE motorless speed reducers and gear motors carry on a 40-year tradition of dependability *plus*. Complete technical information on gear motors, motorless speed reducers, rotary convertors and motor generators supplied free upon request.

Generators

Gear Motors - Convertors

Janette

MANUFACTURING COMPANY

556 WEST MONROE STREET • CHICAGO, ILLINOIS

are businessmen

COLD-BLOODED?

OF COURSE NOT! Literally, their normal body temperature is 98.6—same as laborers, engineers or any other group of people. And, figuratively, they're no more, or no less, cold-blooded—as a group.

We all know unreasonable generalizations can be dangerously false. Common sense and on-the-job experience show us the value of dealing specifically with ideas, problems—and *people.*

Let's not make the big—and costly—mistake, then, of generalizing on religious or racial groups. Adopt and *carry out* these common sense principles:

1. Accept—or reject—people on *their individual worth.*
2. Don't listen to or spread rumors against a race or a religion.
3. Speak up, wherever we are, *against* prejudice. Work for understanding.

A PUBLIC SERVICE PROJECT — THE ADVERTISING COUNCIL

Published in the public interest by:

McGraw-Hill Publications

When it's high pressure... it's AMERICAN!

HYDRAMITE...pressures up to 5000 p.s.i.

High pressure capacity is built into the HYDRAMITE . . . the remarkable new AE radial-piston constant displacement fluid power generator. It has an overall efficiency of 85% without supercharging.

HYDRAMITE is direct-driven through a flexible coupling . . . rotates in either direction. You've the choice of foot, flange or face mounting.

A product of American Engineering Company, makers of the famous Hele-Shaw Pump, HYDRAMITES are already bringing new efficiency and economy on a wide variety of hydraulically-operated equipment. They are available in 3, 5, and 10 g.p.m. oil capacities.

HELE-SHAW . . . variable pressures up to 3000 p.s.i.

The Hele-Shaw is a radial-piston variable displacement fluid power generator. Pressure and reversal of flow are controlled directly at the pump. Discharge can be varied from zero to maximum . . . and can be reversed gradually or instantaneously. Suitable controls available. Capacities range from 3¾ to 50 g.p.m. and upward.

AE

AMERICAN ENGINEERING COMPANY

PHILADELPHIA 25, PENNA.

AE Products include: Hydramite and Hele-Shaw Fluid Power; Taylor and Perfect Spread Stokers, Marine Deck Auxiliaries, Lo-Hed Hoists, Lo-Hed Car Pullers

American Engineering Company
2501 Aramingo Avenue, Philadelphia 25, Pa.

Gentlemen: ☐ Kindly send me complete information about the new HYDRAMITE. ☐ Hele-Shaw.

Name_____ Title____

Company_____

Address_____

City_____ Zone____ State_____

Send for your copy of this

CATALOG TODAY!

60 pages of valuable information describing the line of Honeywell Industrial Controls

THE KIND of information you want, right at your finger tips . . . on pneumatic, electric and electronic non-indicating controls for temperature, pressure and humidity.

Included are many types of switches and relays . . . temperature and pressure controllers . . . many types of valves . . . and scores of other inexpensive, accurate and dependable controls.

Catalog No. 8304 is complete and factual . . . contains detailed specifications for all products, with complete supplementary price lists. It belongs in your files for ready reference . . . send for your copy today.

Also ask to be put on the mailing list for *Industrial Control News*—a periodical publication devoted to new and unusual applications of automatic controls throughout industry. It is written by and for production and maintenance men. Articles are illustrated by drawings and photographs and graphically show how jobs can be made easier, costs reduced and operating efficiency increased.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4459 Wayne Ave., Phila. 44, Pa.

MINNEAPOLIS **Honeywell**

Brown Instruments

Superb **CASTELL** *Prints*

NO LONGER A LUXURY

Famous CASTELL Drawing Pencil with Imported Lead now available to you at practically no extra cost

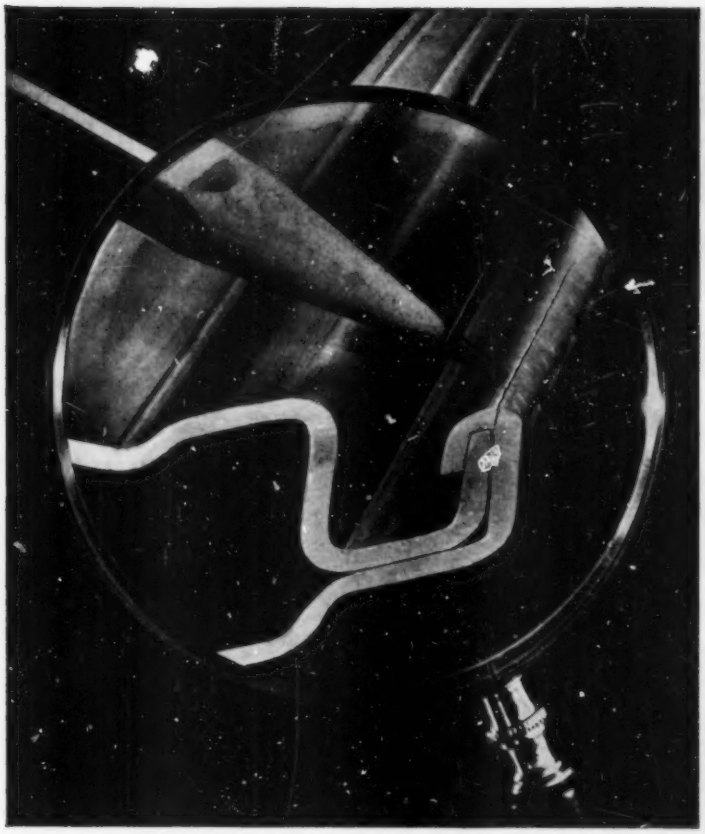
CASTELL DRAWING PENCIL 9000

CASTELL LOCKTITE REFILL HOLDER 9400

"Industry demands legible prints—and the making of legible prints begins on the drawing board," states Mr. E. S. Fairley, of the well-known B. K. Elliott Company, Pittsburgh, Cleveland, Detroit.

We agree with him 100%. Imported CASTELL Lead *always* has produced more sharp copies per original drawing than any other pencil on the market. New price ranges now bring CASTELL with imported lead within reach of craftsmen who heretofore used ordinary drawing pencils. You, too, may now enjoy the use of the world's finest drawing pencil at no extra cost. See your Dealer today.

A.W. FABER-CASTELL PENCIL COMPANY INC. NEWARK 4, N.J.



Case of the fractured bend

Southeastern Tool & Die Company, Birmingham, Alabama, was faced with a serious problem. They were getting fractures while roll-forming structural members from Kaiser Aluminum.

After confirming that the metal met specifications, a Kaiser Aluminum consulting engineer took the first plane to the plant. A leading roll-forming expert, he discovered that the first pass die needed a modification.

He supervised removal and machining of the die to correct tolerance. Result: A smooth-functioning roll-forming operation.

Services of a Kaiser Aluminum consulting engineer are available free of charge to *you*, too.

So, no matter what your products are or whatever form of aluminum you use, call a Kaiser Aluminum consulting engineer if you need technical assistance. 63 sales offices and warehouse distributors in principal cities. Kaiser Aluminum & Chemical Sales, Inc., Oakland, California.

WORKING ACROSS the desk from you or your product engineers, the Kaiser Aluminum consulting engineer can give you valuable assistance in product design and development.

ON YOUR production lines, the Kaiser Aluminum consulting engineer can often suggest changes in alloy, temper, die design, or better fabricating or finishing methods to increase production, decrease costs.

A KAISER ALUMINUM consulting engineer's help is equally valuable today to help you with Defense Orders, or for development of products for future civilian markets.

KAISER ALUMINUM consulting engineers operate from strategically located offices — just a short time away from you. Call any Kaiser Aluminum office, conveniently listed in the phone book yellow section, for immediate service!

Kaiser Aluminum

Setting the pace . . . through quality and service

CONSERVE weight

PRESERVE surface finishes

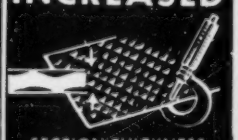
OBSERVE reduced costs

with

Rigidized *design-strengthened textured* **Metals**

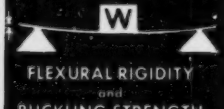
. . . and get

INCREASED



SECTION THICKNESS

GREATER



FLEXURAL RIGIDITY and BUCKLING-STRENGTH

HIGHER

IMPACT STRENGTH

LOWER

MAINTENANCE COSTS

Increased strength-weight ratios, together with its outstanding versatility, make Rigidized Metal a valuable and economical material throughout every industry. A redistribution of metal permits gage reductions that help to conserve strategic materials. Product life is prolonged with the mar-resistant surfaces of this modern metal. Your product will have increased value through your use of Rigidized Metal.

Write on your company letterhead for a copy of the RIGIDIZED METALS CONSERVATION HANDBOOK Today

Rigidized Metals Corporation

6739 OHIO STREET BUFFALO 3, NEW YORK

What makes one man worth $40,000 — another only $4,000? . . . this book tells . . .

HOW TO CULTIVATE YOUR TOP EXECUTIVE QUALITIES . . .

—and win success faster in the upper brackets

TOP EXECUTIVES aren't born. They're made. Self-made mostly. Though they rise along different routes, the steps to their success are similar. They follow a definite course of action . . . and arrive at the top as planned. Now, here is a practical, inspiring book which brings you this amazing success formula. It outlines a specific, detailed plan for cultivating the qualities which mark the top-flight business leader today—illuminating each point with intimate, on-the-job studies of currently outstanding executives.

DEVELOPING YOUR EXECUTIVE ABILITY

By **Howard Smith, Personnel Consultant, Noted Lecturer, and Instructor with Dale Carnegie Institute. 325 pages 5½ x 8, $3.50.**

This book provides a blueprint that shows how you can win executive success. Showing that executive genius is not a quality one is born with, but the result of concentrated effort along the right lines, the book tells how to direct the same efforts and thinking which you already expend daily toward the definite goal of improving your executive ability. Packed with helpful pointers it tells how the up-and-coming executive can make the most of his capabilities, grow in executive stature, and rapidly qualify for the upper bracket responsibilities and rewards.

Some facts this book gives you:

- how to plan advancement
- the secret of executive personality
- 3 best methods for improving personality
- 11 ways to put over your personality
- 24 guideposts to productive thinking
- 11 aids for making decisions
- 11 steps for handling worries
- how to budget time most efficiently
- 12 tested techniques for giving instructions
- how to talk to groups effectively
- how to handle responsibility
- how to give yourself publicity

SEE THIS BOOK TEN DAYS FREE—MAIL COUPON

McGraw-Hill Book Co., 330 W. 42 St., N.Y.C. 18

Send me Smith's Developing Your Executive Ability for 10 days' examination on approval. In 10 days I will send $3.50, plus few cents postage, or return book postpaid. (Postage paid on cash orders.)

Name .....

Address .....

City and State .....

Company .....

Position PPE-9-51

Books sent on approval in U. S. and Canada only.

save time

drive rivets with a hammer

As simple as hammering nails, you can save valuable time on sheet metal assembly jobs with Drive-Pin Rivets. There are no special procedures, no special tools with the Cherry Rivet Company's series of Drive-Pin *blind* Rivets.

When installed, the serrated pin is driven into the tapered hole in the rivet. The surrounding section of the rivet shank is forced expanded into the hole in the material; then the four sections of the protruding end of the shank expand to form a blind head at the back of the work.

Available in six diameters in steel (3/16", 1/4", 5/16", 3/8", 7/16", and 1/2") and three diameters in aluminum (3/16", 1/4", and 5/16"). Grip lengths for material thicknesses from 1/8" to 1 1/16". Brazier and Countersunk (100°) head styles.

Drive-Pin Rivets are ideal for fastening light sheet to heavier sheeting or to framework where rigidity is great enough to withstand hammering. Driving the pin forces the head of the rivet against the top sheet. In turn, the top sheet is forced against the material beneath. The rivet forms a tight head on the blind side.

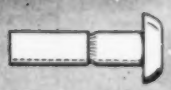
drive-pin rivet advantages

1. Installed by one man working from one side of the job.
2. An ordinary hammer is the only installation tool needed.
3. Requires very little preparatory instruction on the job.
4. Unusually good material thickness tolerance.
5. Hole-filling qualities are exceptional.

FIRST... look to Cherry Rivet Company's complete line of blind rivets and high strength structural bolts.

FIT YOUR FASTENING JOB EXACTLY

CHERRY RIVETS, the standard of industry, are available in more rivet types and a greater range of diameters—grip lengths—and material thickness tolerances than any other blind rivet manufacturer, and many other fasteners.



BLIND BOLT. A large-diameter, blind fastener designed for heavy sheet metal jobs where access to the job is blind or limited. Blind Bolts install fast . . . they have strength characteristics equal to or greater than AN bolts.

LOCK BOLT. A high-strength, structural, non-blind bolt to be used where shear and tension loads are high. Will not loosen in service. Ease of installation saves time. You save considerable weight over nuts and bolts.

Cherry Rivet

COMPANY

A Division of Townsend Company

CHERRY RIVET CO., 231 Winston St., Los Angeles 13, Cal.

Cherry Rivets are approved by U. S. Navy, U. S. Air Force, and Civil Aeronautics Authority. Cherry Rivets are patented.

WRITE FOR DETAILS TODAY!

Cherry Rivet Company, Dept. I-106
231 Winston Street, Los Angeles 13, Calif.

Please send me detailed information on Cherry Rivet Company products as checked here:

- ☐ DRIVE-PIN RIVETS
- ☐ CHERRY BLIND RIVETS
- ☐ LOCK BOLTS
- ☐ CHERRY TOOLS
- ☐ BLIND BOLTS

Name_____ Firm_____

Address_____

City_____ Zone____ State_____

our
Priceless Ingredient
in MOLDED
PLASTICS

Webster defines EXPERIENCE as "Knowledge or special skill resulting from one's continuance in a study or work." We like that definition. It sums up the best we have to offer American Industry. Because good and bad alike, *all* of our experience has contributed to our ever increasing knowledge in the molded plastics field.

What does this experience mean to you as a buyer of molded plastics? It is your assurance that the final design is sound . . . that the mold is engineered and built by experts . . . that the molding is done by the best methods and equipment. AUBURN molds all plastic materials and is completely unbiased as to type or method. Finally, it marks AUBURN as a reliable subcontractor

Injection

Reinforced (Fiberglas)

Transfer

Extrusion

Compression

Automatic Rotary

Sales Engineers

Auburn salesmen are Sales Engineers—not agents — available for consultation with your design engineers. Or, if your design is complete, send us prints for quotations—without obligation.

Auburn Button Works, Inc.
AUBURN, NEW YORK
Founded in 1876 Telephone 3-5320

READY TO PRODUCE . . .

Diefendorf learned all about military requirements meeting the exacting demands of precision production.

All types—all materials. Skillful engineering to help meet current gearing problems. Contract production only.

DIEFENDORF GEAR CORPORATION
Syracuse, New York

DIEFENDORF GEARS

"FATIGUE WEAKNESS OF SURFACES"

Reprints of this valuable 24-page report are once again available! J. O. Almen of the General Motors Research Laboratory presents an analysis and evaluation of weaknesses caused by material fatigue.

This informative article, including helpful photographs, drawings, and graphs, is available at a cost of 50 cents per copy. Write Reader Service Department:

PRODUCT ENGINEERING
McGraw-Hill Building
New York 18, N. Y.

When Choosing V-Belts Remember These Two Words ...They Mean Exactly What They Say!

"DEPENDABLE RUGGEDNESS" didn't get into the BWH trade mark by accident. It means *precisely* what it says . . . Bull Dog V-Belts assure steady, smooth, low cost power transmission — *uninterrupted by premature belt failure.* You save on maintenance costs, keep the wheels of power moving!

TOUGH PROBLEMS INVITED — Ask us or your nearest BWH distributor about your power transmission belting, conveyor belting and hose problems. We're specialists in making mechanical rubber products work *better, longer.*

- **SPECIALLY ENGINEERED BWH CORD SECTION**
  Noted for high tensile strength. *Benefit:* superior load carrying capacity, ability to absorb shock loads, uniform matching when used in sets.
- **MINIMUM STRETCH**
  Results from a new, exclusive technique in processing Bull Dog Cords. *Benefit:* reduced slippage, a minimum of adjustments, longer belt life.
- **DURABLE COVERS**
  The secret's in the closeness of weave of the heavy, bias cut fabric. *Benefit:* it can take the severe wearing action of the sheave while sealing the belt against moisture, dirt and grease.
- **WITHSTANDS SEVEREST FLEXING**
  The "reason why" here is due to constant research in the development of quality - controlled compounds by BWH. *Benefit:* these compounds run cooler and do not crack or deteriorate under severe flexing.

For these reasons make your next V-Belt purchase order read "Bull Dogs" — and buy them by the set!

Another Quality Product of

BOSTON WOVEN HOSE & RUBBER COMPANY

Distributors in all Principal Cities

PLANT: CAMBRIDGE, MASS. • P. O. BOX 1071, BOSTON 3, MASS., U. S. A.

It's time we got *working* mad!

As we listen to the latest insults from Moscow, we're likely to get fighting mad.

Instead, we'd better use our heads and get *working* mad.

It is clear by now that Stalin and his gang respect just one thing—strength. Behind the Iron Curtain they've been building a huge fighting machine while we were reducing ours. Now we must rebuild our defenses—*fast*.

As things stand today, there is just *one* way to prevent World War III. That is to re-arm—to become strong—and to stay that way!

This calls for better productivity all along the line. Not just in making guns, tanks and planes, but in turning out civilian goods, too.

Arms must come first. But we must produce arms *at the same time* we produce civilian goods.

We can do this double job if we all work together to turn out more for every hour we work—if we use our ingenuity to step up productivity.

All of us must now make sacrifices for the common good. But we're working for the biggest reward of all —*peace with freedom!*

THE BETTER WE PRODUCE THE STRONGER WE GROW

A PUBLIC SERVICE PROJECT • THE ADVERTISING COUNCIL •

FOR A FREE COPY OF "THE MIRACLE OF AMERICA"

MAIL THE COUPON to Public Policy Committee, The Advertising Council, Inc., Dept. B.P., 25 West 45th Street, New York 19, N. Y.

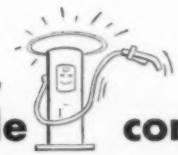
Name .....

Address .....

.....

McGRAW-HILL PUBLISHING COMPANY

How Glass by Corning gave gas pumps a reliable conscience



When you see the paddle wheel spinning, you know gas is being pumped into your car—it's the "gas pump's conscience." Of course it's housed in glass—you've got to be able to see it. But the engineers who designed the pump demanded a lot more of the "glass" than visibility—and got it when they took the problem to Corning.

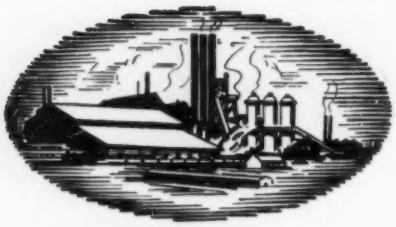
While a simple appearing piece of glass, it has some tricky requirements for safety and dependability. To meet Underwriters' approval, the glass must stand a test pressure of three hundred pounds. In addition, the surface next to the gasket has to be constructed to form a leakproof, vapor-proof seal. It must also resist corrosion. And all tolerances on the glass must be extremely close to accurately fit into the complete assembly.

The point is this: Corning can produce glass components to meet the most exacting design requirements. We've got the glasses with the properties you need, the engineering and research staff, and the production facilities to solve your most complex problem. So, consult with Corning before your idea reaches the blueprint stage. Or, send today for the informative Bulletins B-83, "Properties of Selected Commercial Glasses" and B-84, "Design and Manufacture of Commercial Glassware."

CORNING GLASS WORKS
CORNING, NEW YORK
Corning means research in Glass

1851 • 100 YEARS OF MAKING GLASS BETTER AND MORE USEFUL • 1951
Technical Products Division: **Laboratory Glassware, Signalware, Glass Pipe, Gauge Glasses, Lightingware, Optical Glass, Glass Components**

CORNING GLASS WORKS, Dept. PE-9, Corning, N.Y.
Please send literature checked:
☐ B-83 "Properties of Selected Commercial Glasses."
☐ B-84 "Design and Manufacture of Commercial Glassware."
Name _____ Title _____
Company _____
Address _____
City _____ Zone _____ State _____



1900 ★ THE MIRACLE OF AMERICA ★ 1950

Freedom and Progress

It's no stretch of the imagination, rather, robust realism to call our past half century a Miracle—U. S. A.

America has set an amazing record of progress in 50 years—but a moment in the history of civilization. A record unequalled by any other political or economic system.

Merely by broad brush strokes, we can all visualize this miracle. Remember the crystal set, the hand-cranked car, the biplane? A far cry from our FM radio, television, hydro-matic drive and supersonic planes.

And here's another phase of the miracle that went hand-in-hand with these and the myriad of intertwined technological advances—ranging from the radio telephone and Bakelite to the X-ray tube and teletype . . . and to atomic energy and its untold potentialities.

- Since 1900 we have increased our supply of machine power 4½ times.
- Since 1900 we have more than doubled the output each of us produces for every hour we work.
- Since 1900 we have increased our annual income from less than $2400 per household to about $4000 (in dollars of the same purchasing power), yet . . .
- Since 1900 we have cut 18 hours from our average work week—equivalent to two present average workdays.

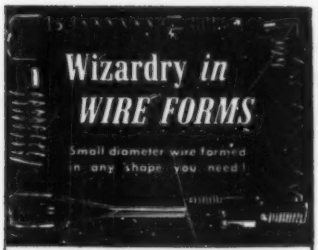
How did we do it? The basic cause for this composite miracle has been the release of human energy through FREEDOM, COMPETITION and OPPORTUNITY. And one of the most important results is the fact that more people are able to enjoy the products of this free energy than in any other system the world has ever known.

THIS IS THE MIRACLE OF AMERICA . . . it's only beginning to unfold.

A PUBLIC SERVICE PROJECT — THE ADVERTISING COUNCIL

Published in the public interest by:

McGraw-Hill Publications



IMMEDIATE CAPACITY FOR DEFENSE SUB-CONTRACTS

STRAIGHTENING & CUTTING
Perfect straight lengths to 12 ft.
.0015 to .125 diameter

WIRE FORMS
.0015 to .080 diameter

SMALL METAL STAMPINGS
.0025 to .035 thickness
.062 to 3 inches wide

★

Specializing in Production of Parts for Electronic and Cathode Ray Tubes

Write for Illustrated Folder
Send Blueprints or Samples for Estimate

ART WIRE & STAMPING CO.
227 High Street Newark 2, N. J.

Send Us Your GASKET PROBLEMS

Vellumoid's wide variety of non-metallic gasket materials and its nearly half-century experience have helped solve many a gasket problem.

Samples for testing purposes gladly sent on request.

VELLUMOID
444 VELLUMOID
VELBESTOS
(Compressed Asbestos)
VELLUTEX
VELBUNA
THIOKOL & BUNA N
Coated Materials

THE **VELLUMOID** CO.
Worcester (6) : Mass.

Can any of these free services help you speed defense production?

New York State offers these aids to defense manufacturers and suppliers

1. Help in Locating Subcontractors. The New York State Department of Commerce, through its "Industrial Preparedness Survey," can supply complete data on plants and equipment suitable for production of specific defense items. A prime contractor can speedily locate the subcontractor he needs.

2. New Plant Site Location. To help you establish new plants or expand current operations, the Department will be glad to recommend appropriate locations available within the State. Information on labor, raw materials, power, water, fuel and transportation will aid your decision. Inspection trips are arranged confidentially.

3. Office in Washington. A New York State office is maintained in the nation's capital to help New York businessmen. This office sets up meetings with the proper personnel; provides information on government agencies; keeps abreast of current regulations and restrictions; aids in preparing applications and other papers needed to carry on business with Federal agencies.

4. Information on Current Federal Purchasing. As part of its service to businessmen, New York State screens notices of Federal procurement opportunities and circulates procurement information to firms within the State.

Write for bulletin

New York State Department of Commerce
Room 115, 112 State St., Albany 7, N. Y.
Please send me a copy of your free bulletin "Defense Services of the New York State Department of Commerce."

*Name*_____
*Position*_____
*Company*_____
*Street*_____
*City*_____ *State*_____

IN WIRE-MESH PRODUCTS LET JELLIFF DO IT!

For 70 years we've been weaving Wire Mesh. And a good part of that time we have also been making things of Wire Mesh for people who find it is cheaper, easier and generally more satisfactory to "let Jelliff do it."

From big Dipping Baskets to tiny precision filters—from fuel strainers to what-is-it gadgets—JELLIFF's Custom Production Department turns out fabricated Wire-Mesh products at speed, price and precision that mean lower costs and a stronger competitive position for our many customers.

If you buy or make wire-mesh assemblies as components of your own products and have not yet had an estimate from Jelliff, write today for details. No obligation, even if you enclose a blueprint for us to figure on. Address Department 24.

THE C. O. JELLIFF MFG. CORP.
DIPPING BASKETS · LEKTROMESH · RESISTANCE WIRE
WIRE MESH PARTS · WIRE CLOTH · STRAINERS · FILTERS
SOUTHPORT · CONNECTICUT

GRC
ZINC ALLOY
WING NUTS
GET AROUND

you'll see them on
GENERAL ELECTRIC
EM-PM FOCUS COILS

. . . and wherever specifications call for fastenings that are rustproof ● corrosion-resistant ● easy to assemble and disassemble ● extra easy to service ● durable, dependable, attractive.

Write for samples and prices today.

Available in all popular thread sizes and commercial finishes. Also specials made to order.

GRIES REPRODUCER CORP.
World's largest producer of die cast Wing Nuts
98 Willow Ave., New York 54, N. Y. ● MO 9-2476

A handy reference on formulas for . . .
• STRESS
• STRAIN
• STRENGTH
of materials

HERE'S your ideal guidebook on strength of materials. It contains extensive tables of formulas and numerous illustrative examples . . . includes the results of intensive analytical and experimental work . . . presents for your quick reference all the formulas for stress, strain, and strength useful to the design-engineer. It also brings you—*step-by-step*—the essential principles used in stress analysis, and provides you with fundamental data on the mechanical properties of materials.

Formulas for Stress and Strain

By RAYMOND J. ROARK
Professor of Mechanics, University of Wisconsin
366 pages, 6 x 9, 43 illustrations
SECOND EDITION, $5.00

PRODUCT DEVELOPMENT SERIES

This practical book takes you from basic definitions through clear statements of general principles, and right on to facts, figures and formulas for the calculation of stress and deflection. You get everything from the principles of superposition and least work to formulas for elastic stability of plates and shells.

Check the partial list of tables this guide puts at your fingertips:

—for straight beams, circular rings and flat plates under a wide variety of conditions of loading and support
—for curved beams and torsion members of various sections
—for thin- and thick-walled pressure vessels
—for rollers and other bodies under direct pressure
—for columns
—for slender bars and thin plates in which failure occurs through elastic instability.

SEE IT 10 DAYS—FREE

McGraw-Hill Book Co., Inc., 330 W 42d St., N. Y. 10
Send me Roark's FORMULAS FOR STRESS AND STRAIN for 10 days' examination on approval. In 10 days I will remit $5.00, plus a few cents for delivery, or return the book. We pay for delivery if you remit with this coupon; same return privilege.

Name .....
Address .....
City ..... Zone.... State.....
Company .....
Position PPE-9-51
Books sent on approval in U. S. and Canada only

UNDISPLAYED RATE

$1.20 per line, minimum 3 lines. To figure advance payment, count 5 average words as a line.

(See ¶ on Box Numbers.)

POSITION WANTED & INDIVIDUAL SELLING OPPORTUNITY undisplayed advertising rate is one-half of above rate, payable in advance.

PROPOSALS $1.20 a line an insertion.

INFORMATION

BOX NUMBERS care publication count as 1 line additional in undisplayed advertisements. DISCOUNT of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals.)

EQUIPMENT WANTED OR FOR SALE Advertisements acceptable only in Displayed Style.

DISPLAYED RATES

The advertising rate is $10.50 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page. P.E.

NEW ADVERTISEMENTS received by 10 A. M. September 20th, in the N.Y.C. office, will appear in the October issue, subject to limitations of space available.

REPLIES (Box No.): Address to office nearest you
NEW YORK: 330 W. 42nd St. (18)
CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

POSITIONS VACANT

WANTED—ENGINEER as assistant to technical research manager of large New York State manufacturer. Some knowledge in the fields of physics, chemistry, electricity and metallurgy required; should have at least five to ten years of broad experience in at least one field. Ability to organize and supervise research groups necessary. Send complete resume of industrial experience and education with letter of application to P-1028, Product Engineering.

PROGRESSIVE FIRM in the metals field with a record of continuous growth, large enough to offer excellent possibilities but small enough to recognize talent, wants to add to its development staff of electrical and metallurgical engineers a metallurgist with good basic education, broad interest, and technological inclinations. Please state in your reply your education, the positions held previously, and the work in which you were engaged. Write Box P-1618, Product Engineering.

WANTED 5 MACHINE Designers for converting machinery. Write qualifications, experience and marital status to St. Regis Paper Company, 130 E. Church Street, Pensacola, Florida.

WELDING ENGINEER. Plant southeastern Pennsylvania doing heavy fabrication of machinery and component parts. Minimum five years experience or B.S. degree, Met., M.E., or Chem. Eng., plus general knowledge of welding techniques and procedures. Contacts with customers and plant technical personnel. Age 30-40. State salary desired first letter. P-1592, Product Engineering.

MEDIUM-SIZED Company with progressive ideas, continually engaged in development work, wants to add to its staff an engineer, electrical, metallurgical, or mechanic, to work on the development and testing of electrical contacts. Previous experience in these fields is desirable but not essential. Our staff knows of this advertisement. Please write Box P-1615, Product Engineering, giving full particulars on education, experience, previous positions, and reasons for change.

EMPLOYMENT SERVICE

SALARIED POSITIONS $3,500 to $35,000. We offer the original personal employment service (established 41 years). Procedure of highest ethical standards is individualized to your personal requirements. Identity covered; present position protected. Ask for particulars. R. W. Bixby, Inc., 268 Dun Bldg., Buffalo 2, N. Y.

SALARIED PERSONNEL $3,000-$25,000. This confidential service, established 1927, is geared to needs of high grade men who seek a change of connection under conditions assuring, if employed, full protection to present position. Send name and address only for details. Personal consultation invited. Jira Thayer Jennings, Dept. H, 241 Orange St., New Haven, Conn.

POSITIONS WANTED

PRODUCT ENGINEER: engineering executive 20 yrs. design & development experience on small electro-mechanical devices. Several patents. Tool & production experience. Now Ch. Eng. of med. small plant. PW-7295, Product Engineering.

PRODUCIBILITY ENGINEERS

Career Opportunities for Experienced Men Seeking Advancement

Positions Available For

DESIGN PRODUCIBILITY ENGINEERS

(Experienced in aircraft design, production and cost)

DESIGN HANDBOOK ENGINEER

(Experienced in technical writing, processes, design requirements and manufacturing techniques)

Apply to Engineering Personnel Manager

NORTHROP AIRCRAFT, INC.

1023 E. Broadway
Hawthorne, California

ENGINEERS • • DESIGNERS

Key positions affording excellent promotional opportunities for graduate engineers with several years design, development and product experience in the following fields as applied to aircraft:

Servo-Mechanisms
Electronic Controls
Automatic Pilots
Electric Motors
Service Engineers
Design Checkers
Electro-Mechanical Design

Leading aircraft accessories manufacturer. Large backlog for development and production. Located in friendly residential city.

Excellent security possibilities due to current and anticipated contracts not totally dependent on rearmament program.

Interviews arranged at Company expense with qualified applicants. Send experience resume to:

Employment Manager
LEAR, INC.
110 Ionia, N.W.
Grand Rapids, Michigan

ENGINEER
PRODUCT DEVELOPMENT

Graduate engineer, capable of handling full responsibility for product development and for manufacturing problems, process, performance of specialized resistors. Permanent opening in our Phila. Plant.

INTERNATIONAL RESISTANCE CO.
401 N. Broad St.
Phila. 8, Pa.

ELECTRICAL ENGINEER

Immediate opening for a Graduate Electrical Engineer to head up a long range development program on the design of fluorescent ballasts and other electrical wiring devices. Man should have several years of development and design experience as well as practical production experience with these products.

Knowledge and experience in illumination engineering desired but not essential as work will eventually include development of test programs along this line.

Position is permanent; plant located in small city, is completely modern; our personnel know of this ad; replies will be kept confidential and personal interview will be arranged; application should include full details; qualifications, picture if available and salary expected.

P-1708, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

DESIGN ENGINEER

Established manufacturer of construction equipment is looking for an engineer with specialized experience in the complete design of front-end loaders. Please write, giving full resume of qualifications and experience. Your reply will be treated with the strictest confidence.

P-1614, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

ENGINEER
SR. ELECTRONIC

Position involves design and development of high frequency components. Applicant must have background in H. F. and V. H. F. techniques. Must be capable of supervising other engineers on work and of co-ordinating entire projects. Permanent position; location Phila.

INTERNATIONAL RESISTANCE CO.
401 N. Broad St.
Phila. 8, Pa.

WANTED

Engineers and Physicists with educational background in mechanical, electrical, or electronic engineering, physics or engineering physics for research and advanced development in plant and laboratory instrumentation, geophysics, physical measurements and industrial electronics. Prefer men with five to fifteen years' experience in experimental research, design and development of instruments, intricate mechanisms, electronic apparatus, optical equipment, servomechanisms and allied fields. Positions are of immediate and permanent importance to our operations. Southwestern location in medium-sized community; excellent employee benefits. Please give age, experience, and other qualifications in reply.

Personnel Director,
Research and Development Dept.
PHILLIPS PETROLEUM COMPANY
Bartlesville, Oklahoma

ENGINEER

Metallurgist-Physicist: Age 34

Executive, research and developmental experience effective for new product development and integration into manufacturing operations. Practical ideas; good research organizer. Competent originator of experimental equipment. Genuine opportunity for advancement most important. Reply care

P-1787, Product Engineering
330 W. 42nd St., New York 18, N. Y.

WANTED
MACHINE and EQUIPMENT DESIGNERS

With experience by well known machine tool builder located in a progressive New England town. Extensive engineering program under way. Give full details of background and experience.

Write directly to *Mr. M. H. Arms*, Chief Engineer.

BRYANT CHUCKING GRINDER CO.
Springfield, Vermont

DO YOU
HAVE THE QUALIFICATIONS TO FILL THIS
POSITION of OPPORTUNITY?

YOU must be

- an experienced — 5 to 15 years — first class product development engineer or special machine designer
- ingenious, resourceful and liking diversification
- capable of taking on product development from scratch to conclusion
- willing to accept a wide latitude of endeavor and responsibility.

If you feel you are the man we need and desire a permanent position—not just an emergency defense job—write today to:

P-1581, Product Engineering
330 W. 42nd St., New York 18, N. Y.

MECHANICAL ENGINEER

Progressive twelve year old company (250 employees) has opening for first rate engineer in product engineering department (16 employees in product engineering). Work consists of research, development, design, and application of specialty accessories for freight cars and tractors. Permanent position; salary commensurate with ability, $6,500 to $10,000; employee insurance and profit-sharing plan. State qualifications and salary expected. Correspondence held in strict confidence. Address Paul K. Boemer, Vice President, Preco Incorporated, 6300 East Slauson Avenue, Los Angeles 22, California.

LABORATORY STAFF ENGINEER

Training in Metallurgical, Mechanical or Electrical Engineering. Experience in Metallurgy and Chemistry in a manufacturing industry doing both production and development laboratory work. Must have had supervisory experience or graduate administrative training. Send comprehensive resume to:

Box P-1426
Product Engineering
330 W. 42nd St., New York 18, N. Y.

FIELD PRODUCT ENGINEER

Obtain and evaluate engineering data received from customers in the field relative to the development of new products. 35%-50% of time spent in field. Age middle 30's. Location Central Connecticut. Please submit resume with salary requirements to

Box PE 774 221 W. 41 St., N. Y.

CONTRACT WORK

BRONZE CASTINGS

SAND

- Up to 150 lb. pcs. closely held to standards.
- Bench work or production runs. Rough or machined. Over forty years experience.
- American Non-Gran Bronze Co., Berwyn, Pa.

NON-GRAN
PRECISION MACHINE WORK
CASTINGS • SAND & CENTRIFUGAL

Write for "Our Story in Pictures"

ENGINEER
MECHANICAL

Graduate M.E., with automatic mechanism design or development experience, to handle machinery development and maintenance problems. The machinery involved is complex and precise assembly equipment. Permanent position in our Phila. plant. Medium sized manufacturing company of 2,000 employees.

INTERNATIONAL RESISTANCE CO.
401 N. Broad St.
Phila. 8, Pa.

POSITION WANTED
(Continued from page 441)

DESIGNER—8 Years' experience analog computers, special machinery, tools. 3 years' engineering college. Age 29. Now living in East, desires to settle permanently in San Francisco or Seattle areas. PW-1761, Product Engineering.

PATENTS

CONSULT: Z. H. POLACHEK.
Reg. Patent Attorney. 1234 Broadway, New York 1, N. Y.

PROFESSIONAL SERVICES

GEORGE H. KENDALL
Consulting Mechanical Engineer
Cost Reduction Studies: Process or Product. Redesign Existing Products for Greater Profit. Trouble Shooting Production, Design, Cost Problems. Specialist Automatic Machinery, Process, Controls, New Developments, Patent Studies, Investigations. New Products & Process Engineering Studies.
P. O. Box 3 *(Est. 1923)* Tel. Darien 5-1504
Noroton Heights Darien, Connecticut

NEW YORK TESTING LABORATORIES, INC.
CHEMICAL, MECHANICAL, ELECTRICAL METALLURGICAL ENGINEERS ANALYTICAL CHEMISTS, PHYSICISTS, X-RAY
Analysis, Tests of all Materials and Products, Plant and Field Services in Special Measurements of Stress, Sound, Vibration and other. Consultants in Litigation and Process Engineering and Design.
80 Washington St. New York City 6, N. Y.

SKINNER, HARLAN AND IRELAND, INC.
Consulting Engineers
Specializing in Magnetic Materials and Their Application
Office and Laboratory Indianapolis 7, Indiana

The Consulting Engineer

By reason of special training, wide experience and tested ability, coupled with professional integrity, brings to his client detached engineering and economic advice that rises above local limitations and encompasses the availability of all modern developments in the fields where he practices as an expert.

Index of PRODUCTS ADVERTISED In This Issue

MATERIALS

Adhesives 100
Aluminum Alloys..2, 33-34, 90, 223, 239, 280, 431
Beryllium Alloys 366
Bimetal..... 90, 282, 365
Brass.....2, 85, 211, 280, 363
Bronze..85, 209, 211, 327, 363, 402
Carbon 420
Carbon Graphite.....94, 106-107
Cemented Carbides 450
Ceramics 358
Copper Alloys.....2, 85, 90, 211, 365, 366
Cork Compositions 80
Fabrics, Coated or Impregnated 439
Friction Materials 227, 396
Glass 268, 437
Graphite 420
Laminated Metals 90, 236, 384, 391
Leather 206
Light Metals 432
Manganese Alloys 90, 402
Molybdenum Alloys 376
Nickel Alloys 66, 73, 88, 211
Nylon 84, 410
Phosphor Bronze 345
Plastics..8, 10, 57, 72, 75, 84, 95, 108, 200, 242, 246, 284-285, 297, 318, 339, 342, 361, 378, 396, 417, 434
Plastics, Laminated.....10, 93, 95, 108
Platinum Alloys 90
Plywood 333
Powdered Metals..94, 106-107, 233, 365, 382
Resins 10, 108
Rubber & Synthetics..63, 206, 237, 242, 268, 284-285, 322, 394, 400, 417, 423, 446
Silicones 198, 268
Silver Alloys 90, 211
Stainless Steel..2nd cover, 61, 70, 88, 202, 292
Steel.....61, 96, 202, 219, 269
Vanadium Alloys 381
Wood 333
Zinc 407

STRUCTURAL PARTS

Bars.....61, 88, 345, 363, 366
Bushings 287, 418, 420
Castings....66, 114, 209, 223, 275, 295, 306, 320-321, 350, 358, 392, 402
Die Castings..52, 72, 206, 229, 245, 288, 379, 392, 440
Extrusions.....33-34, 297, 342, 394, 423, 434
Forgings.....243, 280, 396, 402
Metal Powder Parts...94, 106-107, 227, 233, 382, 420
Plates 269
Pads...2, 33-34, 85, 209, 280, 342, 345, 366, 410
Shapes.....2, 96, 209, 211, 291, 311, 423
Sheets.....2nd cover, 2, 33-34, 345, 423
Stampings..211, 236, 266, 323, 358, 380, 397, 422, 439
Strips....2nd cover, 85, 342, 345, 366, 394, 410, 423
Tubing..2nd cover, 2, 33-34, 61, 70, 82, 85, 202, 209, 219, 221, 291, 320-321, 342, 371, 384, 394, 410, 423, 424, 452
Wire.....50, 85, 345, 366, 384, 439, 440

FINISHES

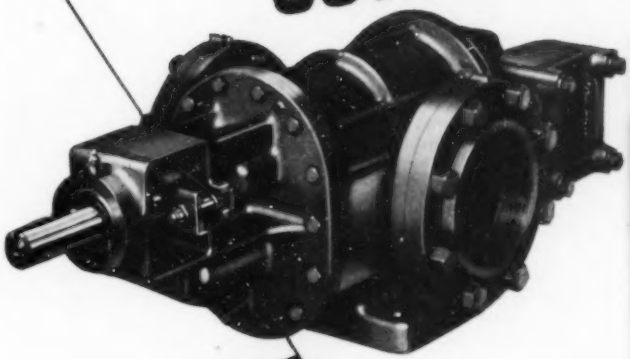
Galvanizing 276, 335
Metal Spraying 335
Paints & Lacquers...286, 389, 413
Plating 368
Rust Proofing 276, 330
Sealants 408

MECHANICAL PARTS

Abrasives 227
Adhesives 100
Air Motors 305
Bearings, Ball, Roller, and Needle..4th cover, 41, 45, 53, 56, 86-87, 109, 118, 231, 241, 264, 287, 296, 298, 538, 369, 396, 405
Bearings, "Oil-less"...94, 106-107, 233, 420

(Continued on page 444)

NEW... 300 G. P. M. COMPACT



ROPER 3600 HBRV No. 7 PUMP

For Petroleum, Process and General Industries

This new model Roper pump is extremely compact for its rated capacity of 300 G.P.M. It features the highly efficient venturi suction and discharge principle for smooth flow; deep packing box with lantern ring to permit effective sealing and long packing life. All components are carefully machined, inspected, and tested to assure dependable performance under prolonged runs. The case can be fitted for steam heated operation at small extra cost... ideal for pumping thick viscous liquids. It can be driven by gasoline engine, geared head motor or truck power take-off for a wide range of applications. Find out now how this Roper 3600 fits into your pumping requirements.

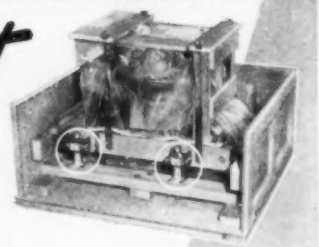
Send for Descriptive Literature

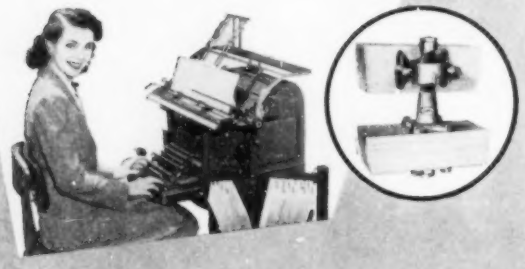
GEO. D. ROPER CORP.
379 Blackhawk Park Ave.
ROCKFORD, ILLINOIS

ROPER Rotary Pumps

LORD SHIPPING MOUNTS *Protect*

BURROUGHS TYPEWRITER ACCOUNTING MACHINES





Inside the plywood shipping cases of Burroughs Typewriter Accounting Machines you will find a brand new kind of protection against damage from accidental dropping and rough handling. Each machine is supported by four LORD Shipping Mounts which cushion shock forces with the controlled softness which only shear-type rubber mountings can provide. Their ability to prevent exposure of the machine to excessive shock forces in all planes insures maximum protection, regardless of the position in which the case may fall.

Extensive tests during the period in which Burroughs Adding Machine Company was considering the use of this new system indicated that LORD Shipping Container Mounts enable a packaged machine to be dropped over 36 inches without damage. The value of such high-quality protection was proved by over 1000 foreign shipments to date which have been delivered in perfect condition . . . without a single loss from breakage.

If you encounter frequent shock damage to shipments . . . if service costs are high at destination . . . if you wish to insure arrival of your products with factory-set adjustments intact — you should investigate LORD Shipping Mounts. Write for complete information . . . see how this new method can cut your shipping losses.

1. Insure safe arrival of shipments through engineered shock mounting design and application.
2. Enable many products to be shipped completely assembled and accurately adjusted.
3. Reduce cost of servicing and parts replacement at destination.
4. May be reused many times.
5. Eliminate need for storage of bulky, inflammable packing materials.

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

Vibration-Control Mountings . . . Bonded-Rubber Parts

Index of PRODUCTS ADVERTISED In This Issue

•

(Continued from page 443)

Bearings, Sleeve . . . 53, 94, 106-107, 264, 275, 327, 363, 365, 420
Bellows . . . 48, 99, 344, 376
Belts . . . 43, 51, 59, 103, 227, 264, 324-325, 419, 422, 435
Bolts, Nuts, Screws and Rivets 49, 79, 217, 235, 236, 247, 262, 279, 326, 351, 352, 360, 370, 386, 388, 403, 409, 412, 414, 416, 433, 440
Blowers . . . 427
Brakes . . . 16, 81, 312
Bushings & Grommets . . . 233, 287, 363, 365
Carburetors . . . 372
Chains . . . 11, 20-21, 54, 276, 281, 334, 421
Clamps . . . 240, 352, 376
Clutches . . . 74, 81, 264, 274, 350
Collars . . . 235
Compressors . . . 51, 59, 103, 286
Containers . . . 313, 422
Controls . . . 277, 322, 422
Counters . . . 17
Couplings, Flexible . . . 53, 54, 248, 281, 299, 377, 444, 447
Couplings, Hose & Tube . . 240, 253, 257, 452
Dampers . . . 238
Drives . . . 11, 15, 20-21, 24-25, 37, 51, 54, 59, 81, 103, 274, 281, 304, 374, 378
Engines . . . 256, 278, 380
Fan Blades . . . 427
Fasteners . . . 33-34, 47, 49, 77, 79, 89, 116, 211, 217, 235, 236, 247, 262, 279, 326, 351, 352, 360, 370, 386, 388, 394, 403, 409, 412, 414, 416, 424, 433, 440
Filters . . 322, 372, 390, 396, 426, 440
Flexible Joints . . . 251
Floats . . . 234
Gages & Instruments . . . 213, 357, 380, 401
Gears . . 6, 35, 37, 53, 71, 112, 252, 263, 272, 277, 278, 289, 290, 301, 304, 390, 406, 408, 418, 434, 447
Handles . . . 342
Hose . . . 227, 344, 362, 452
Hydraulic & Pneumatic Equipment . . . 1, 40, 78, 258-259, 274, 286, 305, 308-309, 312, 322, 334, 352, 355, 367, 368, 370, 383, 395, 400, 404, 422, 429, 448
Locks, Hinges . . . 399
Lubricating Equipment . . 245, 267, 343, 346
Materials Handling . . 15, 26-27-28-29, 307, 429
Mountings . . . 238, 444
Name Plates . . . 264, 402
Packing, Gaskets, Seals . . . 69, 80, 94, 98, 106-107, 206, 227, 237, 240, 250, 253, 267, 268, 310, 335, 342, 356, 378, 394, 400, 420, 427, 449
Photographic Equipment . . . 293
Pins . . . 394, 424
Piping . . . 213, 219, 320-321
Plugs . . . 235
Power Units . . 40, 78, 258-259, 286, 305, 355, 383, 395, 404, 429
Pumps . . . 26-27-28-29, 43, 51, 59, 103, 258-259, 286, 307, 334, 340, 355, 357, 362, 364, 373, 383, 388, 395, 429, 443, 447, 448
Rings . . 77, 89, 94, 106-107, 268, 342, 384, 394, 449
Riveting Machines . . . 40
Screens . . . 396
Screw Machine Parts . . . 280
Shafts . . . 20-21
Shafting Flexible . . . 326, 374
Sheaves & Pulleys . . . 43, 51, 59, 103, 264
Shims . . . 236
Speed Reducers & Motor Reducers . . 3rd cover, 24-25, 35, 37, 43, 46, 53, 71, 81, 91, 264, 271, 277, 289, 302-303, 304 331-332, 387, 411, 418, 427
Spindles . . . 249
Springs . . . 36, 232, 359, 397
Sprockets . . . 11, 53, 54, 278, 281, 421
Strainers . . . 396, 440
Testing Equipment . . 213, 256, 308-309, 357, 380, 401

Index of PRODUCTS ADVERTISED In This Issue

Tapes 322
Thermometers 72, 200
Thermostats 48
Timers 408
Transmissions ... 15, 20-21, 24-25, 37, 51, 59, 103, 264, 378
Traps 213, 234
Universal Joints 53, 386
Valves & Fittings .. 1, 40, 213, 234, 253, 258-259, 352, 368, 412, 416, 422, 430, 448
Vibration Dampers 80, 238, 400, 444
Washers .. 89, 233, 237, 266, 315, 394
Wire Cloth 215, 270, 422, 440

ELECTRICAL PARTS

Actuators 376
Brakes 336-337
Brushes 94, 106-107, 420
Clutches 336-337
Coils 268, 360
Connectors 44, 92
Contacts .. 4, 12-13, 60, 90, 260, 384, 391, 402
Controls & Control Equipment 4, 12-13, 18-19, 22-23, 30-31, 43, 55, 60, 67-68, 81, 91, 101-102, 104-105, 252, 254-255, 256, 260, 314-315, 319, 326, 350, 353, 379, 386, 393, 402, 420, 425, 430
Cords 348, 423
Counters 370
Drives 35
Electronic Equipment 401, 445
Fans & Blowers 307, 425
Generators 38-39, 385
Heating Units 83, 322, 375
Instruments ... 12-13, 256, 385, 401
Insulators 358
Lamps 390
Magnets 294
Motors ... 3rd cover, 12-13, 18-19, 26-27-28-29, 32, 35, 38-39, 43, 46, 64-65, 76, 91, 97, 244, 256, 271, 273, 283, 302-303, 307, 331-332, 362, 368, 372, 382, 385, 387, 411, 412, 425, 427
Rectifiers 12-13
Rings 233
Solenoids .. 12-13, 322, 370, 416, 430
Telephones 268
Thermostats 62, 319, 350, 420, 430, 451
Timers 32, 64-65, 256, 368, 372, 408
Transformers 268
Vibrators 60
Wire & Cable 42, 72, 200, 348
Wiring Accessories 12-13, 92, 328-329, 348, 358

DRAFTING ROOM EQUIPMENT AND SUPPLIES

234, 265, 293, 306, 316-317, 340, 349, 430

FABRICATING METHODS AND SUPPLIES

Brazing 396
Drawing 335
Enameling 335
Extruding 237, 242, 297
Forming 58, 335, 439
Gear Cutting 6
Honing 14, 347
Materials Handling 421
Molding .. 95, 237, 242, 246, 261, 297, 322, 326, 357, 358, 394, 423, 434, 446
Plating 396
Pressing 40, 357
Riveting 40
Rolling 311
Shearing 396
Spinning 374
Stamping 266, 335, 380, 396, 422, 439
Swaging 276, 334
Welding 4, 60, 225, 300, 335, 341, 396, 415

ENGINEERING AND PRODUCTION SERVICES

14, 58, 248, 300, 311, 335, 354, 416

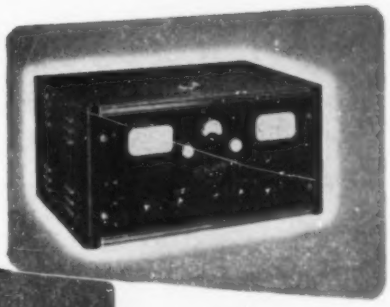
BOOKS

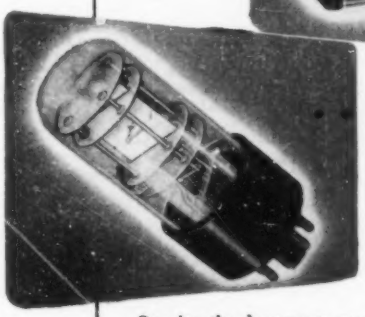
364, 384, 400, 404, 406, 410, 414, 416, 422, 432, 440

JK CRYSTALS

Supplying TODAY'S NEEDS

Ever see a frequency monitor better than its crystal? The JKO-3 crystal used in this Doolittle monitor is the finest available — as are all JK crystals used everywhere.





. . . and DESIGNING TOMORROW'S

Opening the doorway to new crystal uses is the newly announced JK G-9. The glass envelope in which the crystal is hermetically sealed provides a sure vacuum for higher Q, resistance is unaffected by supersonic reflections.

EVEN A JK CRYSTAL FOR PASTEURIZING BEER!

Tomorrow's needs for crystals are constantly met today by the James Knights research laboratories. Take the case of a new JK supersonic crystal now in use with a well-known brewery for pasteurizing beer. The JK crystal was designed to kill the bacteria — without heat — simply by vibration! Another dramatic crystal application made possible by James Knights' ability to fill any specific need crystal-wise! Whether for new product design or laboratory research, consult James Knights FIRST.

Write for free catalog—listing all JK crystals, their specifications and schematics.

THE JAMES KNIGHTS COMPANY
SANDWICH 4, ILLINOIS

CRYSTALS FOR THE CRITICAL

No crystal is "outdated" with James Knights. We can furnish yesterday's crystals as well as all present-day applications — PLUS designing new crystals for still unheard of uses.

Roth makes Rubber Resist 500° F. Heat

Roth makes Rubber Resist -110° Cold

Roth makes Rubber Resist Oil and Gas

Roth makes Rubber Resist Weather and Abrasion

Roth makes Rubber Bond to Metal

Roth makes Rubber to Your Specifications

RR ROTH RESEARCH BRINGS RESULTS WITH RUBBER!

WRITE, WIRE OR PHONE...

Roth will gladly help you develop bids, quote on present rubber requirements or create a special formula to cut costs, boost output or simplify production.

RR ROTH RUBBER COMPANY

1864 S. 54th Avenue • Chicago 50

Custom Manufacturers of Industrial Rubber Products since 1923

INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate, but PRODUCT ENGINEERING assumes no responsibility for errors or omissions.

Accurate Spring Mfg. Co. 359
Acro Mfg. Co. 402
Adel Division, General Metals Corp. 334
Advance Pressure Casting, Inc. 379
Ahlberg Bearing Co. 338
Airborne Accessories Corp. 390
Aircraft-Marine Products Co. 328-329
Ajax Flexible Coupling Co. 377
Alemite 343
Allegheny Ludlum Steel Corp. 292
Allen-Bradley Co. 67-68
Allis Co., Louis 387
Allis-Chalmers Mfg. Co. 43, 59
Allis-Chalmers Mfg. Co., Tractor Div. 380
Allmetal Screw Products Co., Inc. 262
Alumicast Corp. 392
Aluminum Industries, Inc. 223
American Brass Co. 211
American Engineering Co., Hydraulics Div. 429
American Fort-Pitt Spring Div., H. K. Porter Co., Inc. 232
American Hard Rubber Co. 242
American Insulator Corp. 261
American Manganese Bronze Co. 402
American Metal Hose Branch, American Brass Co. 452
American Smelting & Refining Co. 209
American Steel & Wire Co. 50
American Welding & Mfg Co. 300
Anchor Coupling Co., Inc. 257
Anti-Corrosive Metal Products Co. Inc. 414
Arkwright Finishing Co. 265
Armco Steel Corp. 202
Armstrong Cork Co. (Gaskets, Packings & Seals) 80
Arrowhead Rubber Co. 263
Art Wire & Stamping Co. 439
Arwood Precision Casting Corp. 358
Atlas Powder Co. 413
Auburn Button Works, Inc. 434
Automatic Electric Sales Corp 393
Automatic Valve Co. 370
Automotive Gear Work, Inc. ... 263

Bakelite Co. A Div. Union Carbide & Carbon Corp. ...10, 108
Baldor Electric Co. 273
Baldwin-Lima-Hamilton Corp. Testing Div. 308-309
Barber-Colman Co. 412
Barco Mfg. Co. 251
Barnes Co., Wallace, Div. Associated Spring Corp. 36
Barry Corp. 238
Bead Chain Mfg. Co. 276, 335
Beldon Mfg. Co. 348
Bellows Co. 305
Bendix-Westinghouse Automotive Air Brake Company ... 312
Berkeley Scientific Corp. 370
Beryllium Corp. 366
Bethlehem Steel Co. 96
Blood Brothers Machine Co. .. 386
Bodine Electric Co. 411
Bolta Co. 396
Bond, Inc., Charles 418
Boston Gear Works 53
Boston Woven Hose & Rubber Co. 435
Bound Brook Oil-less Bearing Co. 233
Breeze Corporation, Inc. 376
Bridgeport Brass Co. 85
Brown & Sharpe Mfg. Co. 401
Brunino Co., Inc., Chas. 349
Bundy Tubing Co. 371
Bunting Brass & Bronze Co. .. 363

Cambridge Wire Cloth Co. 422
Carboloy Co., Inc. 450

INDEX TO ADVERTISERS

Carlyle Johnson Machine Co.... 74
Carpenter Steel Co.... 88
Carpenter Steel Co. Alloy Tube Div.... 70
Cash Valve Mfg. Corp., A. W. 412
Casting Engineers, Inc.... 350
Chace Co., W. M.... 282
Chemical Corp.... 276
Cherry Rivet Co. Div. of Townsend Co.... 433
Chicago Metal Hose Corp.... 344
Chicago Rawhide Mfg. Co.... 206
Chicago Thrift-Etching Corp.. 402
Clare & Co., C. P.....30-31
Clark Controller Co.....104-105
Cleveland Cap Screw Co.... 360
Cleveland Worm & Gear Co... 71
Clifford Mfg. Co.... 99
Climax Molybdenum Co.... 376
Columbia Steel Co.... 50
Continental Screw Co.... 351
Corning Glass Works.... 437
Coto-Coil Co., Inc.... 360
Cramer Co., Inc. R. W.... 256
Crane Co.... 213
Cuno Engineering Corp.... 426

Dayton Rogers Mfg. Co.... 422
Dayton Rubber Co.....324-325
Denison Engineering Co...258-259
Dial Light Co. of America.... 390
Diefendorf Gear Corp.... 434
Dixie Cowdrey Machine Corp. 416
Dodge Mfg. Corp.... 264
Doerr Electric Corp.... 362
Douglas Fir Plywood Assn... 333
Dow Chemical Co.... 57
Dow Corning Corp.... 198
Driv-Lok Pin Co.... 394
Drop Forging Association 243
duPont de Nemours & Co., Inc., E. I. Fabrics & Finishes 93
duPont de Nemours & Co., Inc., E. I. (Neoprene).... 63
duPont de Nemours & Co., Inc., E. I. (Plastics).... 84
Durakool, Inc.... 252
Durez Plastics & Chemicals, Inc.... 339
Dynamatic Corp., subs. Eaton Mfg. Co.... 81

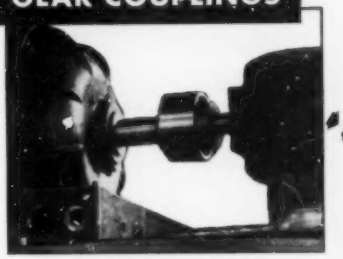
Earle Gear & Machine Co.... 408
Eastman Kodak Co., Industrial Photographic.... 293
Eaton Mfg. Co. Dynamatic Corp.... 81
Eaton Mfg Co., Foundry Div. 114
Eaton Mfg. Co., Reliance Div. 89
Edison Co., Thomas A.... 451
Elastic Stop Nut Corp. of America.... 217
Electric Auto-Lite Co.....72, 200
Electric Boat Co. Electro Dynamic Div.... 97
Electro Dynamic Div. Electric Boat Co.... 97
Elliott Co.....38-39
Emerson Electric Mfg. Co....425

Faber-Castell Pencil Co., A. W. 430
Fairfield Mfg. Co.... 272
Fafnir Bearing Co.... 241
Fairbanks-Morse Co. ..26-27-28-29
Farrel-Birmingham Co., Inc... 289
Federal Bearings Co., Inc.... 87
Federal Mogul Corp. (Equipment).... 365
Federal Telephone & Radio Corp.... 42
Felt Products Mfg. Co.... 340
Fenwal, Inc.... 316
Fischer Special Mfg. Co.... 416
Foote Bros. Gear & Machine Corp.... 35
Foote Gear Works, Brad.... 112
Friez Instrument Div. Bendix Aviation Corp.... 342
Fulton Syphon Div., Robertshaw-Fulton Controls Co.... 48

Galland-Henning Mfg. Co.... 352
Garlock Packing Co.... 356

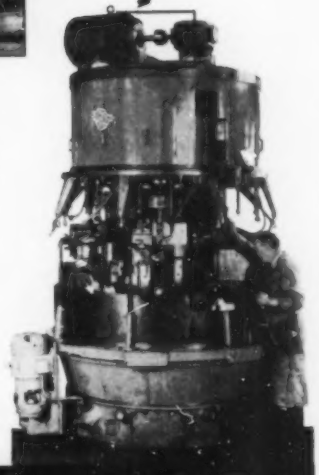
(Continued on page 448)

New Sier-Bath FLEXIBLE GEAR COUPLINGS



..... Used On This

BULLARD MULT-AU-MATIC

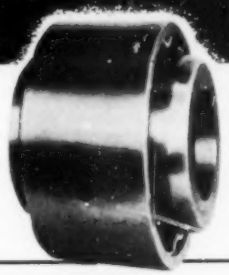


SIZE 2½ Standard Sier-Bath Gear Coupling connecting the 50 HP motor with the main drive of a Type "D" 6-Spindle Bullard Mult-Au-Matic. This coupling may also be used on the 8-Spindle Mult-Au-Matic, connecting the 60 HP motor with the main drive.

SIER-BATH GEAR COUPLINGS PROVIDE THESE ADVANTAGES:

- Cut Coupling Weight 50%
- Cut Coupling Size 40%
- Reduce Coupling Assembly Time
- Reduce Uncoupling Time
- Lessen Strain on Shafts, Bearings
- Reduce Coupling Parts Problems
- Increase Safety

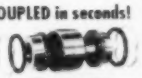
Cut Costs---Improve Your Products with Sier-Bath GEAR COUPLINGS



MORE and more well-known manufacturers are modernizing their direct drives with the revolutionary Sier-Bath Gear Couplings. Light, compact, stream-lined—these new couplings eliminate bolts, nuts, grids, discs—reduce the gear coupling principle to its simplest, most efficient form. They provide plenty of flexibility, transmit the whole load from hub to hub by means of a powerful, one-piece smooth sleeve. No bolts to shear, seize or corrode . . . faster alignment checks . . . less maintenance . . . longer life.

ASSEMBLED, UNCOUPLED in seconds!

ONLY 7 PARTS



⅓ USUAL SIZE
½ USUAL WEIGHT

Sier-Bath Gear Coupling compared with two major conventional types of same shaft size, HP rating.

WRITE FOR BULLETIN—gives installation photos, cost-cutting advantages, plan drawings, specs for standard, vertical, mill motor and floating shaft types—sizes from ⅞ to 6, HP 4 to 550. (Special sizes and types on request.)

Founded 1905 Member A.G.M.A.

Sier-Bath GEAR and PUMP CO., Inc.

9238 HUDSON BLVD., NORTH BERGEN, N. J.

Also Manufacturers of Precision Gears and Screw and Gearex Rotary Pumps.

PAY OFF WHERE THE GOING IS TOUGH

Bulldozers and all types of earth-moving equipment normally operate under conditions imposing heavy mechanical and hydraulic loads on the hydraulic system. American Tractor and Equipment Company uses HYDRECO 3000 Series Pump on their Model TD14W Heavy-Duty Dozer. Like many other heavy-duty equipment manufacturers, ATECO knows that HYDRECO Pumps are made to take abuse. Look at the cutaway view . . . note the simple design — large area roller bearings — sturdy spur gears — high pressure oil seal — renewable wear plates — and most important of all, the four-bolt construction. HYDRECO Four-Bolt design locates the assembly bolts close within the area of greatest internal pressure, insuring rigidity and stability that cannot be equalled. HYDRECO Four-Bolt Pumps, available for all standard mountings, and made to operate in either direction. Five basic sizes — ½ GPM to 130 GPM and for operating pressures up to 1000 p.s.i. to 1500 p.s.i.

Model B.H.F. — TD14W ATECO Inside Mounted Dozer completely equipped with HYDRECO Controls.

Send for complete information including detailed performance data.

HYDRAULIC EQUIPMENT COMPANY

1112 EAST 222ND STREET • CLEVELAND 17, OHIO

INDEX TO ADVERTISERS

(Continued from page 447)

Gast Mfg. Corp. 286
General Electric Co., Apparatus Dept. 12-13, 55, 83
General Electric Co., Chemical Dept., Plastics Div..... 95
General Industries Co. 244
Gerbing Mfg. Corp..... 378
Gering Products, Inc..... 342
Gerotor May Corp..... 395
Geuder, Paeschke & Frey Co. Contract Div. 335
Gits Bros. Mfg. Co..... 267
Gleason Works 6
Goodrich Chemical Co., B. F. (Hycar) 8
Goodrich Co. B. F. (Rivnut).. 79
Graton & Knight Co..... 449
Great American Industries, Inc., Rubatex Div..... 400
Gries Reproducer Corp..... 440
Groov-Pin Corp. 424

Hannifin Corp. 40
Hansen Mfg. Co., Inc..... 372
Hardchromers Inc. 368
Harper Co., H. M..... 352
Haydon Co., A. W..... 368
Haydon Mfg. Co., Inc..... 64-65
Heim Co. 56
Heli-Coil Corp. 418
Holliday & Co., Inc., W. J.... 269
Holliston Mills, Inc..... 234
Holtzer-Cabot Co. Division of National Pneumatic Co., Inc. 46
Houghton & Co., E. F. 310
Howard Industries 283
Hyatt Bearings Div., General Motors Corp. 41
Hydraulic Equipment Co..... 448

Imperial Tracing Cloth Co..... 340
Indiana Gear Works..... 406
Indiana Steel Product Co..... 294
International Nickel Co., Inc. Monel 66
International Nickel Co., Inc. Nickel Alloy 73
International Packings Corp... 449

Janette Mfg. Co..... 427
Jeffrey Mfg. Co..... 421
Jelliff Mfg. Corp., C. O..... 440
Johns-Manville Corp. (Packings) 98
Johnson Bronze Co. 327
Johnson Machine Co., Carlyle 74

Kaiser Aluminum & Chemical Corp. 239, 431
Kaydon Engineering Corp.... 231
Keuffel & Esser Co.....316-317
Knights Co., James..... 445
Kollsman Instrument Corp.... 385
Koppers Co., Inc. (Fast's Coupling) 299
Koppers Co., Inc. Plastics Div. 361
Koven & Bros. Inc., L. O..... 354
Kraissl Co. 364

Lamb Electric Co..... 271
Laminated Shim Co., Inc. (Laminum) 236
Lamson & Sessions Co..... 49
Lapeer Mfg. Co..... 352
Lapiant-Choate Mfg. Co..... 355
Leach Relay Co..... 386
Leake Stamping Co..... 380
Lefax 416
Lincoln Electric Co..... 225
Linde Air Products Co., Unit of Union Carbide & Carbon Corp. 415
Linear Inc. 342
Link-Belt Co. ..... .11, 15, 37, 45
Lord Mfg. Co..... 444

McGill Mfg. Co., Inc..... 369
McGraw-Hill Book Co., Inc... 384

INDEX TO ADVERTISERS

McGraw-Hill Catalog Service. 364
Madison-Kipp Corporation ... 245
Mahon Co., R. C. 341
Makepeace Co., D. E. 391
Mallory Co., Inc., P. R. ..4, 60
Manhattan Mfg. & Belting Co.. 419
Marman Products Co. Inc..... 240
Marsh Corp., Jas. P. 380
Massachusetts Gear & Tool Co. 252
Master Electric Co. (Speed-master) .....3rd Cover
Mechanical Air Controls, Inc. 368
Meehanite Metal Corp. 295
Metals & Controls Corp., General Plate Div. 90
Metals & Controls Corp., Spencer Thermostat Div..... 62
Michigan Tool Co., Cone Drive Div. 304
Micromatic Hone Corp. 14
Micro Switch Div. Minneapolis-Honeywell Regulator Co...22-23
Midland Industrial Finishes Co. 286
Miller Motor Co. 301
Mills Corp., Elmer E. 297
Minneapolis-Honeywell Regulator Co. (Industrial Div.)... 430
Minnesota Mining & Mfg. Co.. 100
Monsanto Chemical Co..... 75
Moraine Products Div. General Motors Corp. 382
Morse Chain Co. 20-21
Mt. Vernon Die Casting Co. .. 52
Mueller Brass Co. 280

National Bearing Div., Amer. Brake Shoe Co. 275
National Motor Bearing Co., Inc. 69
National Screw & Mfg. Co.... 409
Newark Wire Cloth Co. 270
New Departure Div. of Gen. Motors Corp. 118
New Jersey Zinc Co. 407
New York State, Dept of Commerce 439
Nice Ball Bearing Co. 398
Nicholson & Co., W. H. 234
Norgren Co., C. A. 346
Norma-Hoffman Bearings Corp. 296
North American Aviation, Inc. 388

Oberdorfer Foundries, Inc..... 373
Ohio Seamless Tube Co..... 221
Ohmite Mfg. Co. 101-102
Onan & Sons, Inc. D. W..... 278
Ortman-Miller Machine Co..... 367
Owens-Corning Fiberglas Corp. Plastics Reinforcement 318

Palnut Co. 386
Parker Appliance Co. 253
Parker-Kalon Corp. 403
Parker Rust Proof Co. 330
Patton-MacGuyer Co. 358
Peck & Harvey 306
Peerless Electric Co. 382
Perkins Machine & Gear Co... 290
Pesco Products Co. Borg Warner Corp. 383
Pheoll Mfg. Co. 326
Philadelphia Gear Works 277
Phosphor Bronze Corp..... 345
Pittsfield Products, Inc. 396
Plastic Research Products Inc. 246
Pneu-Trol Devices, Inc. 422
Polymer Corp. 410
Pope Machinery Corp. 249
Porter Co., Inc., H. K..... 232
Precision Tube Co. 424
Product Engineering 110-111
Progressive Mfg. Co. 412
Pure Carbon Co., Inc. 420

R. B. M. Division of Essex Wire Corp. 260
Racine Tool & Machine Co. .. 340
Ramsey Chain Co., Inc. 281

(Continued on page 450)

SOLVED:

How to get PACKINGS — Synthetic Rubber or Leather — from one dependable source

In leather it's tannage, impregnant, mechanical accuracy . . .

In synthetic rubber it's compound, mould design, and more accuracy . . .

In both it's engineering, with laboratory and production know-how that give you specification-plus on your requirements.

At G&K-INTERNATIONAL modern facilities for the design and manufacture of synthetic and leather packings give you *one dependable supply source* for the best in V's, U's, Cups, Flanges, Oil Seals — also O-Rings and special applications. Let's go over the plans together.

For PACKINGS in Grakone (Synthetic) and Leather

IPC

INTERNATIONAL PACKINGS CORPORATION

BRISTOL, NEW HAMPSHIRE

AFFILIATED WITH GRATON & KNIGHT COMPANY

GRATON & KNIGHT COMPANY
WORCESTER, MASSACHUSETTS

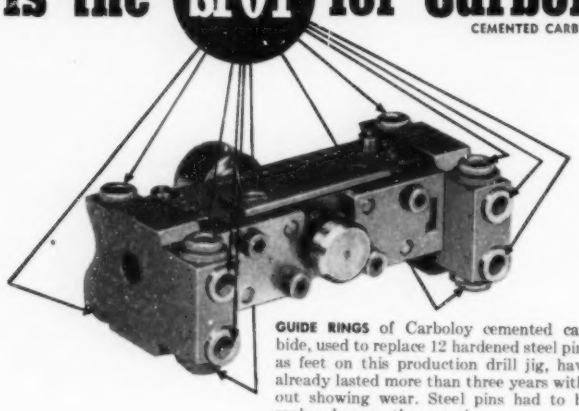
GRATON AND KNIGHT

Since 1851

100 YEARS OF SERVICE TO INDUSTRY

Where there's WEAR is the SPOT for Carboloy

CEMENTED CARBIDE



GUIDE RINGS of Carboloy cemented carbide, used to replace 12 hardened steel pins as feet on this production drill jig, have already lasted more than three years without showing wear. Steel pins had to be replaced every three weeks.

Keep vital equipment like this drill jig in operation, reduce maintenance and costly down-time with Carboloy cemented carbides

THIS manufacturer of electric meters and measuring instruments, who solved a wear problem by substituting Carboloy guide rings, is typical of companies that are using wear-resistant Carboloy cemented carbides to keep vital equipment running, and operating at peak efficiency.

Manufacturers in widely diversified lines have found that Carboloy cemented carbides combat wear, improve quality and increase the life of machine parts or products as much as 100 times.

In this critical period, when it is essential to prolong life of machines and equipment and keep maintenance to a minimum, why not find out how Carboloy cemented carbides can help you do the job? Write: Carboloy Department of General Electric Company, 11105 E. 8 Mile Blvd., Detroit 32, Michigan.

***Positively* reduces wear**

CARBOLOY®

THE QUALITY BRAND OF CEMENTED CARBIDES

"Carboloy" is the trade-mark for the products of Carboloy Department of General Electric Company

INDEX TO ADVERTISERS

(Continued from page 449)

Raybestos Manhattan Inc., Equipment Sales Div. 227
Raymond Mfg. Co., Div. Associated Spring Corp. 397
Redmond Co., Inc. 76
Reeves Pulley Co. 24-25
Reliance Electric & Engineering Co. 331-332
Republic Steel Corp. Steel & Tubes Div. 219
Revere Copper & Brass Inc. ... 2
Reynolds Metals Co., Aluminum Div. 33-34
Reynolds Wire Div. National Standard Co. 215
Rhodes, Inc., M. H. 408
Rigidized Metals Corp. 432
Robbins & Myers, Inc. 307
Robertshaw-Fulton Controls Co. 420
Rockford Clutch Div., Borg-Warner 350
Roll Formed Products Co. 311
Rollway Bearing Co., Inc. 405
Roper Corp., Geo. D. 443
Ross Operating Valve Co. 1
Roth Rubber Co. 446

SKF Industries, Inc. 298
Schatz Mfg. Co. 86
Scintilla Magneto Div., Bendix Aviation Corp. (Electrical Connectors) 44
Scovill Mfg. Co. (Industrial Fasteners) 279, 370
Sessions Clock Co., Tyni-Switch Div. 353
Sewall Mfg. Co., E. B. 278
Seymour Mfg. Co. The 345
Sharon Steel Corp. ..... 2nd Cover
Shenango-Penn Mold Co. 306
Sier Bath Gear & Pump Co. ... 447
Simmons Fastener Corp. 47
Skinner Electric Valve Div., The Skinner Chuck Co. ... 416
Skinner Purifiers Div., Bendix Aviation Corp. 390
Southern Friction Materials Co. 396
Spincraft, Inc. 374
Sponge Rubber Products Co. .. 423
Square D Company 314-315
Stalwart Rubber Co. 237
Standard Pressed Steel Co. 235, 388
Standard Products Co. 323
Standard Varnish Works 389
Stewart Warner Corp. Alemite 343
Stewart Die Casting, Div. Stewart Warner Corp. 229
Stokes Machine Co., F. J. 357
Stow Mfg. Co. 374
Sunnen Products Co. 347

Telechron Dept. General Electric Co. 32
Tennessee Coal, Iron & Railroad Co. 50
Thomas & Betts 92
Thomas Flexible Coupling Co. 248
Thomson Industries, Inc. 287
Timken-Detroit Axle Co. Brake Div. 16
Timken Roller Bearing Co. (Industrial) ..... 4th Cover
Timken Roller Bearing Co. (Steel & Tubes) 61
Tinnerman Products, Inc. 116
Tomkins-Johnson Co. 404
Torrington Co. 248
Torrington Co. (Needle Bearings) 109
Townsend Co. 247
Trostel & Sons Co., Albert ... 250
Tuthill Pump Co. 362
Tuttle & Kift, Inc. 375
Twin City Die Casting 288
Twin Disc Clutch Co. 274

Union Carbide & Carbon Corp. Bakelite Company 10, 108
Linde Air Products Co. 414

INDEX TO ADVERTISERS

Union Plate & Wire Co. 384
United Electric Controls Co. .. 350
U. S. Gasket Co. 378
U. S. Graphite Co. 94, 106-107
U. S. Pipe & Foundry Co. (Special Products) 320-321
U. S. Rubber Co. (Mechanical Goods) 417
U. S. Rubber Co. (Royalite) 284-285
U. S. Steel Company 50
U. S. Steel Export Co. 50
Universal Clay Products Co... 358
Universal Metal Hose Co. 362

Vanadium Corp. of America.. 381
Van Cleef Bros. Inc. 322
Van Huffel Tube Corp. 291
Veeder-Root Inc. 17
Vellumoid Co. 439
Vickers, Inc. 78
Viking Pump Co. 388
Vulcan Electric Co. 322

Wagner Electric Corp. 302-303
Waldes-Kohinoor, Inc. 77
Ward Leonard Electric Co..254-255
Warner Electric Brake & Clutch Co. 336-337
Waterman Engineering Co. ... 322
Western Felt Works 394
Western Sealant Co., Inc..... 408
Westinghouse Electric Corp. 18-19, 91
Wheeler Insulated Wire Co... 268
White Dental Mfg. Co., S. S... 326
Whitney Chain Co. 54
Williams & Co., J. H. 396
Wirebound Box Mfgs. Assn. .. 313
Wisconsin Motor Corp. 266
Wolverine Tube Div., Calumet & Hecla Cons. Copper Co... 82
Worthington Pump & Machy Corp. Allspeed Drive Div. .. 51
Worthington Pump & Machy Corp. Multi-V Drive Sales Div. 103
Wrought Washer Mfg. Co. ... 265

Yale & Towne Mfg. Co. 399
Yoder Co. 58

Zenith Carburetor Div., Bendix Aviation Corp. 372

■

PROFESSIONAL SERVICES.... 442

■

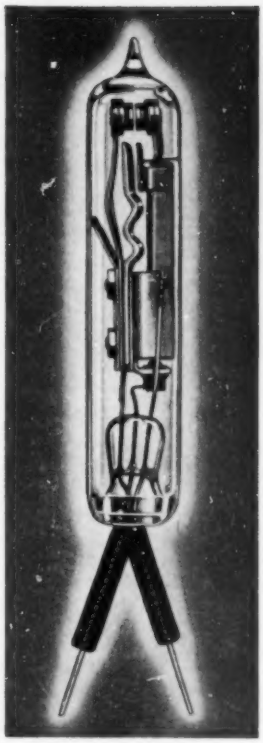
SEARCHLIGHT SECTION
(Classified Advertising)

EMPLOYMENT
Positions Vacant.....441, 442
Positions Wanted.....441, 442
Employment Services..... 441

SPECIAL SERVICES
Contract Work..... 442

■

Advertisers' Index starts on 446
Product Index starts on... 443



Brains in GLASS... to last a lifetime

EDISON

THERMOSTATS operate quietly for years, free from outside contamination

Sturdy glass is the perfect enclosure to protect the fine mechanism of these EDISON Thermostats. Sealed-in-glass means freedom from powdered particles, corrosive gases, calibration drift and contact arcing. And, since the entire unit is isolated in an inert gas, time (measured in years) has no apparent effect, whether the contacts operate every few seconds or remain dormant—as in fire alarm devices.

FOR AIR

EDISON THERMOSTATS are available in several standard mountings. Send fo free Bulletin No. P-3009.

SPECIFICATIONS:

Vibration.....031" amplitude at 60 cps.
Impact.....50 g.
Contact load.....8 amperes max. to 250 V. ac/dc
Temperature.....320° C max.

FOR SOLIDS

FOR LIQUIDS

Thomas A Edison
INCORPORATED

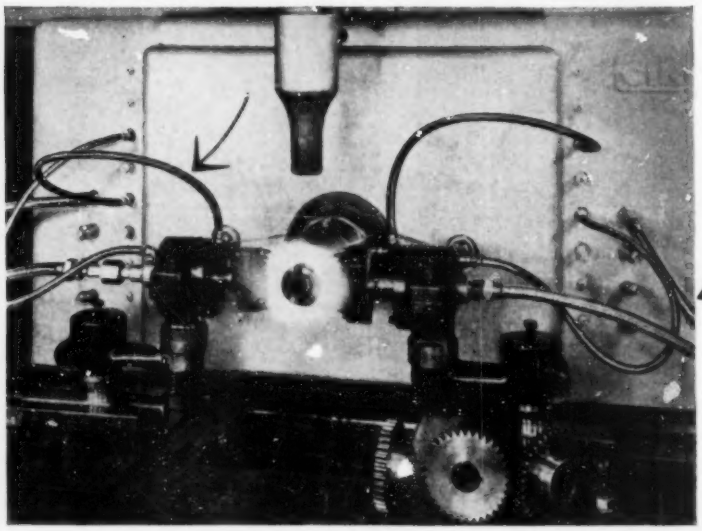
Instrument Division
West Orange • New Jersey

OTHER INSTRUMENT DIVISION PRODUCTS

Sealed Time Delay Relays • Sensitive Relays • Electronic Temperature Controls • Critical Temperature Monitors • Electrical Resistance Bulbs.

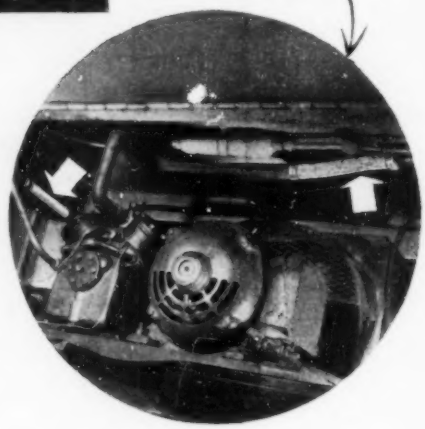
YOU CAN ALWAYS RELY ON EDISON

What kind of work does a **Flexible** connector do?



On this electronically controlled Cincinnati Flamatic Hardening Machine, 3/16" I.D. American Flexible Bronze Seamless Tubing connects the water coolant inlet and outlet lines to the adjustable flame heads. Similar 1/2" I.D. Seamless Tubing conveys gas for the hardening flame.

American Vibration Eliminators isolate compressor line vibration on this truck refrigeration unit installation which was made by The Schnabel Co. of Pittsburgh. Freon gas at 180-200 lb. pressure is carried in the lines.



If connectors must move, absorb vibration, make short bends, connect misaligned ports or make cramped connections, that's the kind of work American Flexible Metal Hose and Seamless Flexible Tubing are designed to do.

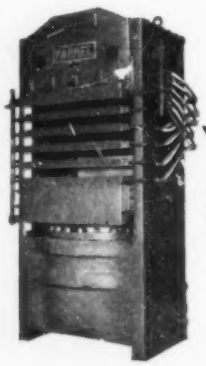
They can convey liquids, gas and semisolids under severe conditions of temperature, pressure and corrosion. They supply protective armor for flexible drive shafts, delicate instrument tubing and electrical wiring.

Bulletins SS-50 and CC-300 illustrate the versatility of American Flexible Metal Hose and Seamless Tubing and the many types available. Let us send you copies. The American Brass Company, American Metal Hose Branch, Waterbury 20, Connecticut. In Canada: The Canadian Fairbanks-Morse Company, Ltd.

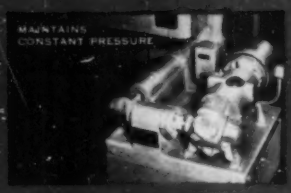
wherever connectors must move . . .

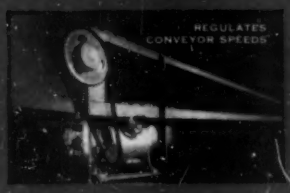
American ANACONDA

FLEXIBLE METAL HOSE AND TUBING



American Bracketubes are used on this Farrel-Birmingham 42" x 42" vulcanizing press to carry steam to the platens.





again and again

variable speed operation

makes a good job better

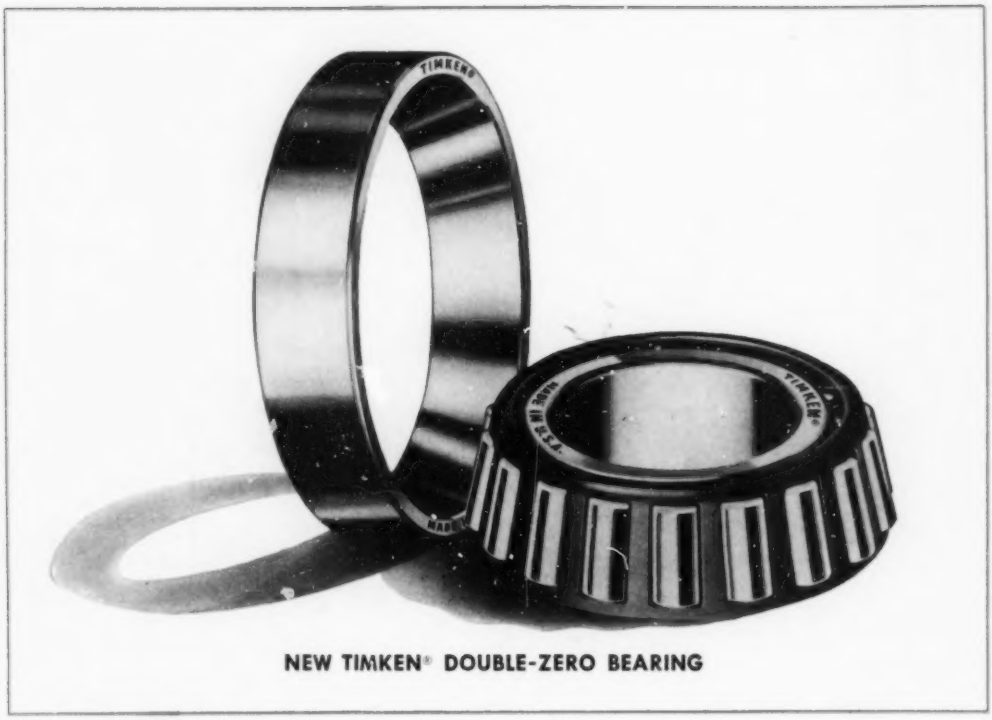
Better because variable speed operation pays off in higher rates of production, a more uniform better quality product and more efficient performance of your equipment and your operators.

Make the job better still by using Master Speedrangers because their all-metal construction makes them extremely compact and durable . . . more flexible and adaptable to a wide range of uses. They're available in sizes up to 5 horsepower with speed ranges up to 12 to 1 in most sizes.

Write for descriptive booklet Data 7525 and see how Master Speedrangers can help you get better results on material processing, handling and conveying equipment . . . mixers and agitators . . . machine tool drives . . . testing and calibrating equipment and many other applications.

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

MASTER SPEEDRANGERS



NEW TIMKEN® DOUBLE-ZERO BEARING

Why we made this bearing so accurate that almost nobody uses it

THIS new Timken® bearing is twice as accurate as any Timken bearing previously made. It has a maximum run-out tolerance of only 75 millionths of an inch. Not many industries are using this bearing . . . yet. It is used mainly on high-speed lathe spindles, precision grinding machine work heads, gear cutting machines, precision rolling mills, and in other applications where extra-high accuracy is important.

But the development of the Timken "Double-Zero" bearing is important to *every* tapered roller bearing user. Experience gained in producing the "Double-Zero" bearing is showing the way to greater and greater precision in *all* Timken tapered roller bearings. Increased precision means greater bearing capacities, permitting the use of smaller bearings at lower cost.

Just as today's standard bearing was the super precision bearing of a few years ago, the new "Double-Zero" bearing of today may well become the standard Timken bearing of tomorrow. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST →◫← LOADS OR ANY COMBINATION